Paper for 8th New Zealand Finance Colloquium, Hamilton, January 2004

THE EFFICIENCY OF NEW ZEALAND'S RETAIL BANKS, 2000 – 2002

Prasad Vedula

David Tripe*

Centre for Banking Studies

Massey University

Private Bag 11-222

Palmerston North

New Zealand

Abstract:

This study reviews the efficiency of the 6 banks with significant retail business and branch networks over the period 2000-2002. 14 different Data Envelopment Analysis (DEA) models, using multiple inputs and outputs, are applied to the data in a single window, so as to overcome the problem of limited sample size.

A surprisingly high degree of overall efficiency is found, although there is some evidence for differences in efficiency between banks. The findings generate some valuable insights into the performance of New Zealand banks, over and above what would be available through simple ratio analysis.

* Corresponding author: E-mail D.W.Tripe@massey.ac.nz; phone +64 6 350 5799 ext 2337; fax +64 6 350 5651.

I. Introduction

The banking industry is a vital part of any country's financial system because it provides a major source of financial intermediation and plays a major part in a country's payments system. Evaluating banks' overall performance and monitoring their financial condition, of which assessment of efficiency is a key part, is important to depositors, owners, potential investors, managers and regulators. If financial institutions become more efficient, we might expect improved profitability, greater amounts of funds intermediated, better prices and service quality for consumers, greater safety and soundness and better returns to shareholders. Bank efficiency can be regarded as socially beneficial, since it minimizes the costs of financial intermediation, i.e., reducing the wastage of real resources due to the transfer of funds from savers to producers. Consequently policy makers are interested in the adoption of operating practices and market equilibria consistent with maximum productive efficiency (Resti, 1997).

Financial ratios are a popular approach to measuring a bank's financial soundness and the quality of its management. Bank management typically express cost performance in terms of two ratios – the ratio of operating costs to average total assets, and the ratio of operating costs to gross income[1]. Both of these ratios have limitations since they are capable of being manipulated through changing accounting practices. Further, complications can arise in comparing banks' ratios because differences in banks' pattern of business and structure are not reflected in the ratios (Tripe, 2003). Evaluating the economic performance of banks requires consideration of a number of criteria like profits, liquidity, asset quality, attitude toward risk, and management strategies. For bankers, achievement of efficiency is made more important by the squeeze on margins, sharper competition, and reduction in regulatory constraints. Therefore the search for efficiency has become both more compelling and complex, requiring more flexible alternative forms of formal efficiency analysis and more sophisticated quantitative techniques.

[1] The cost to income ratio is probably more popular with bank managements, since it has an intuitive appeal in terms of incorporating both key elements of the profit equation, so that, other things being equal, a lower cost to income ratio should imply greater profitability (Tripe, 2003). For a more extensive discussion of cost to income ratio, see Tripe (1998).

To take account of the different mix and pattern of business between banks, we must look at financial firms on a multiple input and multi-product basis rather than using simple ratios (Tripe, 2003). Banks use a mixture of inputs to produce a mixture of outputs, and their reported aggregate cost figures will depend just as much on the mix of inputs and outputs as on the rate at which they use those inputs to product outputs (Mester, 1987). A financial firm is said to be operating inefficiently if it can produce more output without a corresponding relative increase in inputs, or if it can reduce its use of inputs without a corresponding relative decrease in output (Tripe, 2003).

Efficiency can be defined in terms of the extent to which a decision-making unit (DMU), typically a business, can increase its outputs without increasing its inputs, or reduce its inputs without reducing its outputs (Liu & Tripe, 2002). A unit will be 100% efficient if there is no scope for improvement in the ratio in which it converts inputs to outputs. Types of efficiency include scale, scope and *x*-efficiency. Scale efficiency measures whether banks are operating at an efficient level of output; scope efficiency measures whether banks are operating with an efficient mix of outputs; and *x*-efficiency focuses on the effectiveness with which banks are converting inputs to outputs. Specification of *x*-efficiency generally occurs relative to an efficiency frontier, with firms' efficiency being defined in terms of their relative distance from the frontier, which then becomes the benchmark for optimum performance.

The problems of prior literature on scale and scope efficiencies are discussed by Berger et al. (1993) and Berger & Mester (1997). Studies on economies of scale and scope commonly assume a uniform production function that applies to all firms in the market: if two firms are producing the same mix of outputs at the same volume, their costs will be the same. This may not be a reasonable assumption. Berger et al. (1993) suggest that "managerial ability to control costs or maximize revenues appear to be greater than the cost effects of the choice of scale and scope of production" (p 222).

The examination of x-efficiency in banking has important public policy implications. Berger et al. (1993), reported that *x*-inefficiencies account for around 20% or more of costs in banking, whereas scale and scope (product mix) inefficiencies are usually found to account for less than 5% of the costs.

This study investigates *x*-efficiency in New Zealand banks during the period 2000-2002, using Data Envelopment Analysis (DEA), which is a non-parametric approach. The major reason for using this in preference to the alternative, parametric approaches has been the small sample size. DEA has previously been subject to a number of criticisms, but developments since the technique was first outlined by Charnes et al (1978) have seen increased robustness (Seiford & Thrall, 1990) and extension in the application of the methodology (Coelli, 1996).

The rest of the paper is organized as follows. Section II provides an explanation of the efficiency frontier and outlines DEA in particular. Section III provides an overview of previous efficiency studies. Section IV sets out the research methodology and design. The results and discussion are presented in section V. Section VI concludes.

II. The Efficiency frontier and DEA

The absence of any standard set of production processes in banking makes it difficult to specify a standard production function, against which the performance of individual financial institutions can be measured. A common solution to this is to use frontier analysis, based on concepts introduced by Farrell (1957), with the frontier comprising benchmark level of optimum performance. The main advantage of frontier efficiency over other indicators of performance is that it is an objectively determined quantitative measure that removes the effects of market prices and other exogenous factors influencing observed performance (Bauer, et al, 1998). Berger and Humphrey (1997) suggest that frontier analysis is essentially a sophisticated way to benchmark the relative performance of production units and help managers to improve performance by identifying "best" and "worst practices" associated with high and low measured efficiency (p.175).

Attempts to determine the position of the efficiency frontier are dependent on use of accounting information and any other measures of input or output volume that may be available. There are five different approaches to determining the efficiency frontier. The three parametric approaches to specification of the efficiency frontier are the

stochastic frontier approach (SFA), the distribution-free approach (DFA) and the thick frontier approach (TFA), while the two non-parametric approaches are DEA and the free disposal hull (FDH) method.[2] The parametric approaches require specification of a functional form for the cost, profit or production relationship between inputs, outputs and environmental factors. The problem with specifying a functional relationship is that it presupposes the shape of the efficiency frontier, and for the translog approximation in particular, this can generate misleading interpretations in relation to economies of scale and scope (Berger and Humphrey, 1997; McAllister and McManus, 1993).

DEA and FDH are non-parametric approaches to specification of the best-practice frontier. Bauer et al. (1998) state that an obvious benefit of DEA is that it does not need the explicit specifications of a functional form and imposes very little structure on the shape of the efficient frontier and so captures the interplay between various inputs and outputs of different dimensions. The major difficulty with the non-parametric approaches is that they cannot distinguish random error arising from measurement error or extraordinary financial performance. Exception events unrelated to the fundamental economic performance of the DMU can cause its apparent efficiency to be overstated, thus making other DMUs look comparatively inefficient (Berger & Humphrey, 1997; Bauer et al., 1998).

Berger and Humphrey (1997) have suggested that DEA is the most widely used approach, at least in banking. They argue that "parametric frontier approaches commit the sin of imposing a particular functional form (and associated behavioural assumptions) that presupposes the shape of frontier…. if the functional form is misspecified, measured efficiency may be confounded with the specification error" (p.179).

DEA is a linear programming technique initially developed by Charnes et al. (1978) to evaluate the efficiency of public sector non-profit organizations. It measures efficiency by estimating an empirical frontier representing the highest values of outputs/benefits that could be generated by inputs/resources as given by a range of

[2] Classifications of approaches to frontier analysis sometimes ignore the FDH approach, which may be regarded as a special case of DEA.

observed input/output measures. DEA calculates the relative efficiency scores of various Decision-Making Units (DMUs) in the particular sample, in terms of their distance from the efficient (best practice) frontier. The relative score is normally expressed as a number between 0 and 100% or 0 and 1. A unit with a score less than 100% or 1 is regarded as inefficient relative to other units in the sample.

DEA also gives a comparative ratio of weighted outputs to inputs for each DMU. This can assist in identifying possible peers or role models as well as simple efficiency scores, which can give DEA an edge over other methods. Note that the DMUs could be banks or branches of banks.

DEA shows fewer problems when working with a limited sample size and is thus considered appropriate for use in New Zealand where there were only 18 registered banks (as at 30 June 2003) and the sample data under consideration is for 6 banks.

III Overview of efficiency studies

Although numerous studies have been undertaken on bank efficiency over the last twenty years, scope remains for further research, with only very little work having been undertaken in New Zealand. Initial efforts undertaken internationally were inclined to be focused on looking for economies of scale and scope, whereas more recent studies have been more focused on investigation of *x*-inefficiencies. Berger and Humphrey (1997) have provided a comprehensive review of 130 efficiency studies of financial institutions in 21 countries.

There has been little empirical research on bank efficiency in Australia and New Zealand as the small number of banks makes it difficult to conduct econometric analysis. Rather more research has been undertaken on credit unions and other non-bank financial institutions, the numbers of which are rather greater, and which therefore provide more scope for statistical and econometric exploration.

With regard to *x*-efficiency in banks, in Australia, Valentine and Williamson (1982), using a multiple product cost function estimation and data from the 1970s, could not

find conclusive evidence of scale efficiency. Walker (1998) looked to measure scale economies in Australian banks using a multi-product translog function model and data for the period 1978-1990, and found stronger evidence of economies of scale for Australian banks. Walker looked at *x*-efficiencies in Australian banking using a fixed effects version of the stochastic frontier approach, but observed that the limited number of banks posed difficulties in establishing a suitable efficiency frontier.

Avkiran (1999) measured operating efficiencies, employee productivity, profit performance and average relative efficiency of Australian trading banks for the period from 1986 to 1995 using DEA. He also looked at the extent to which efficiency gains were passed on to the public and whether mergers should be promoted for efficiency gains.

Sathye (2001) used DEA to study efficiency in Australian banks in 1996 (a period subsequent to those studied by Walker and Avkiran) and compared the efficiency indices of Australian banks with those of other countries. He also explored the sources of Australian bank efficiency. The study found that banks in Australia had low levels of overall efficiency compared with banks in Europe and the U.S.A. As a source of overall inefficiency, the technical component was found to be more important than the allocative component. The study attributed the inefficiency in Australian banks to technical inefficiency or wasting of inputs.

In the first reported application of DEA to the New Zealand banking sector, Liu and Tripe (2002) used DEA to explore the efficiency impacts of 6 bank mergers in New Zealand between 1989 and 1998. They concluded that acquiring banks were generally larger than their targets, although they were not consistently more efficient. In majority of cases the mergers led to an increase in efficiency. The authors could not draw any firm conclusions on possible public benefits from the mergers.

Tripe (2003) explored the extent of efficiency improvements achieved by New Zealand banks over the period 1996 to 2002, using DEA, on a time-series, rather than cross-sectional basis. The study found evidence for improvements in bank efficiency through time, and attributed this partly to falls in general levels of interest rates and technical progress, and partly to management effort to improve bank efficiency. The

study also provided insights into complications that can arise with use of DEA methodology.

IV. Research design and Methodology

This study uses DEA on data for the six major banks in New Zealand for the three-year period from 2000 to 2002 to study their efficiency. It uses fourteen different models with different sets of inputs and outputs in an effort to prevent results being dominated by any unusual outcomes from any one model, and to avoid prejudging the suitability of any particular model. This study takes lead from the suggestions of future research by Liu and Tripe (2002) by using modified DEA models including risk factors, the number of staff and branches and several other inputs and outputs. The period covered is subsequent to that in Liu and Tripe's study.

For defining inputs and outputs, prior studies adopt either the production or intermediation approach. Under the production approach, a financial institution is defined as a producer of services for account holders, that is, they perform transactions on deposit accounts and process documents such as loans. Hence, according to this approach, the number of accounts or their related transactions best measures output. Sherman and Gold (1985), Ferrier and Lovell (1990), and Fried et al. (1993) follow this approach. The inputs include the number of employees and physical capital (fixed assets).

Under the intermediation approach, financial intermediaries are institutions that convert and transfer financial assets between surplus and deficit units. Output may be defined as the dollar value of deposits and loans while inputs include labour, fixed assets and equipments and loanable funds. This study uses the intermediation approach, which has been found to be more relevant for financial institutions because it includes interest expense, which in recent years in New Zealand has accounted for more than two-thirds of total costs. Further, limitations in the data available for the New Zealand and Australian markets tend to mean that the production approach cannot generally be used, although it could provide some basis for looking at

customer transaction behaviour, which is an important contributor to both banks' costs and revenues.

This study uses the DEAP software developed by Coelli (1996), to calculate the overall x-efficiency scores of New Zealand banks in the sample. The data on inputs and outputs have been collected from the banks' annual reports and the KPMG Financial Institution Performance Surveys (KPMG, 2001, 2002).

Although there are currently 18 banks registered in New Zealand, the sample population comprises only the 6 major banks with branch networks, which together hold more than 85% of the country's total banking assets. These banks are the ANZ Banking Group (New Zealand) Limited (ANZ), ASB Bank Limited (ASB), Bank of New Zealand (BNZ), the National Bank of New Zealand Limited (NBNZ), TSB Bank Limited (TSB) and Westpac Banking Corporation (Westpac).

The study employs a type of window analysis whereby data for the 6 banks for three consecutive years have been included in the analysis together, by treating them as if they represent different banks. This gets around a (*degrees-of-freedom* type) problem of sample size relative to the number of DMUs being studied. It also allows comparison of banks' performance at different times and with the performance of other banks at the same and other times. The larger sample size also allows more scope to identify potential outliers or rogue results.

The sample size in this study (6 banks for the years 2000, 2001 and 2002 totaling to 18) is consistent with other small sample size studies undertaken using DEA. A rule of thumb commonly used with DEA suggests that the number of observations in the data set should be at least three times the sum of the number of input and output variables (Cooper et al, 2000, p 252).[3] That is not to say, however, that DEA will not generate better results with larger data sets, and Berger et al (1997) identify a major problem with prior studies of bank branch efficiency as the small number of observations relative to the input, output and environmental variables (p 145).

[3] There is an alternative expression by Dyson et al (2001, p 248), which says that the number of observations should be at least twice the product of the number of inputs and outputs.

This study uses the CCR (constant returns to scale) model[4], which assumes that outputs change in direct proportion to the change in inputs, regardless of the size of the DMU. Under the alternative, BCC (variable returns to scale)[5] model, each unit is compared only against other units of similar size, rather than against all other units. This assumption of variable returns to scale is thus more suitable for a large sample. Use of a variable returns to scale model may make banks of different size appear to be efficient, just because there are relatively few banks of comparable size against which they can be compared. Tripe (2003) found that scale was unreliable as a cause of the observed improvement in the efficiency of banks in New Zealand over time.

The selection of inputs and outputs in the different models is based on the different versions of the intermediation approach which include the asset approach, which uses funds as inputs and loans as outputs, the user cost approach, which looks at the various contributions to banks' net revenue, and the value added approach, where inputs and outputs are identified according to their share of value added. Input and output specification in the current study has necessarily been the result of compromise between desirable model formulation and the available data. For example, data on demand deposits is not reported separately by New Zealand banks, which limits our ability to use these as a measure of either input or output.

The role of deposits has been debated extensively in the efficiency measurement literature. While some argue that deposits are an input to the production of loans (intermediation, or asset approach), other researchers argue that they are an output, involving the creation of value added (value added approach or user cost approach), along with loans. According to a study on US banks these two financial products absorb 78% of total expenses for labour and capital (Berger and Humphrey, 1992). This study has considered both approaches by including deposits as input in some models and as output in some others. This enhances the discriminatory power of the study since DEA analysis is sensitive to the choice of variables and allows efficiency

[4]The term CCR refers to Charnes, Cooper and Rhodes, who were the authors of the paper in which the model was originally outlined. Constant returns to scale is a common assumption in DEA analysis. Under the assumption of constant returns to scale, input minimization and output maximization models give the same relative efficiency scores. Models can be run on either an input minimization or output maximization basis.

[5] BCC stands for Banker, Charnes, and Cooper, who were the authors of the paper in which this model was originally outlined

measurement from various perspectives. The inputs and outputs of the 14 different models used (along with references to studies using similar models) are listed in Table 1. Reflecting New Zealand banks' prevailing focus on costs, the models have been run on an input minimisation rather than output maximisation basis.

Reflecting the user cost approach, model 1 uses as input variables interest and operating expenses, being the costs incurred to generate both interest and non interest income (which are the model's outputs). The operating expenses reflect use of resources to receive customer deposits, make loans and monitor customers' borrowings, resulting in generation of operating income (net interest income plus non-interest income).

Model 2 uses the value-added approach (another part of the intermediation approach), with inputs being the same as model 1 but a different set of outputs – operating income, customer deposits and loans and advances. This also helps to test the results obtained in model 1.

Model 3 has been run to focus more directly on staff efficiencies by segregating staff expense from operating expense and using it as an input. In model 4 deposits and staff expense replace interest expense (from model 1) and non-interest expense as inputs while advances become a proxy output for interest income.

Models 5, 6, 7 and 8 are run with deposits on the input side but with different combinations of other inputs and outputs to show better discriminatory power and also to examine the sensitivity of the results to changes in the model design.

Model 9 has been run to focus more directly on staff efficiencies on the input side and the impact of non-interest income on the output side. In model 10 the income and expense variables (from model 2) have been replaced with fixed assets and branch numbers on the input side and operating income has been omitted on the output side to test the sensitivity of the results. To specifically test the efficiency of staff, staff numbers have been added as an additional input in model 11.

MODEL NO.	INPUTS	OUTPUTS	REFERENCES IN SIMILAR STUDIES
1	Interest expense, Operating expense	Net interest income, non-interest income	Liu & Tripe 2003, Model 1; Tripe 2003
2	Interest expense, Operating expense	Deposits, Advances, Gross operating income	Liu & Tripe 2003 Model 3
3	Interest expense, staff expense	Net interest income, non-interest income	Avkiran 1999
4	Staff Expense, Deposits	Advances, Non-interest income	Avkiran 1999 Model B (Variant)
5	Branch Numbers, Deposits, Fixed assets	Advances, Gross interest income	
6	Branch Numbers, Deposits, Fixed assets	Advances, Gross operating income	
7	Branch numbers, Deposits, Staff numbers	Advances, Gross operating income	
8	Branch numbers, Deposits and Staff expense	Advances, Gross operating income	
9	Staff numbers, Deposits	Advances, Non-interest income	Avkiran 1999 Model B
10	Branch numbers, Fixed assets	Deposits, Advances	
11.	Branch numbers, Fixed assets, Staff numbers	Deposits, Advances	
12	Staff expense, Fixed assets, Loanable funds	Deposits, Advances	Sathye, 2001
13	Staff expense, Loanable funds	Advances, Net interest income	Sathye, 2001 (Variant)
14	Staff numbers, loanable funds	Advances, Net interest income	Sathye, 2001 (Variant)

In model 12, following the user costs approach, staff expense has been used as a measure of labour. Fixed assets are taken as a proxy for physical capital while loanable funds include all deposits and other borrowed funds. The outputs are

represented by the dollar value of deposits and advances. Models 13 and 14 focus on income generation on the output side while focusing on staff efficiency on the input side.

V. Results and Discussion

The results of DEA under the 14 models are summarized in Table 2. Table 3 summarizes mean and standard deviation of the technical efficiencies of all the models. In table 4 we present the average scores for each bank over the three-year period and table 5 summarizes the averages. The efficiency estimates derived from the different models show consistency in their efficiency levels, rankings, and identification of best and worst banks, consistent over time and with competitive conditions in the market and consistent with standard non-frontier measure of performance such as return on assets or the cost/revenue ratio (not reported). The efficiency scores from different models rank the banks in approximately the same order over time and demonstrate reasonable stability (Bauer, et al., 1998).

The general finding from the results reported is that the overall average efficiency of major New Zealand banks is quite high, with it also appearing to have improved during the study period. Only five out of the 14 models show an average efficiency of less that 90% and most of the models show efficiencies greater than 90%. The overall efficiency score in all the models ranging from 86% to 96% is higher than the mean efficiency of 79% (with range 31% to 97%) reported by Berger and Humphrey (1997, p.185). These results are consistent with the with the conclusions of the studies made by Liu and Tripe (2002) and Tripe (2003) wherein mean DEA scores increased for the banking sector in 1990s due to greater emphasis by banks on efficiency and cost reductions.

The range of efficiency scores thus appear to be higher than in many other studies. This might indicate that banks in New Zealand have sustained the improvements in their efficiency over time, in line with the international trends reported in studies from Australia and the United States. It will, however, also be a reflection of the relatively

small sample (which means that a relatively greater proportion of the sample will be on the efficient frontier).

To test our finding that efficiency of New Zealand banks has improved over time, we have also computed (Table 6) the average technical efficiency scores of banks excluding models 10 and 11 (which show a strong time series effect – explained in a subsequent paragraph). The results suggest improvements in the efficiency scores of the banks across all models, to support the contention that the efficiency of New Zealand banks has improved over the study period.

The low dispersion the scores of the best and worst banks in different models also indicates that banks in New Zealand cannot afford to have significant differences in their efficiencies[6] and New Zealand banking sector is fairly competitive. This is consistent with the view that in a low-growth population, maturing markets are likely to lead to fiercer competition (Avkiran, 1999). The entry of Kiwibank and Superbank, the activities of non-bank lenders and the efforts of major banks to build their markets shares indicate that New Zealand banking sector is fairly competitive, consistent with the above finding.

The averages across the 14 models as shown in table 2 indicate that the efficiency scores of the four major banks are over 90% and there are no significant differences in the efficiency scores. The differences in scores in individual models suggests that some of the findings emerging from DEA studies may be a reflection of the methodology and model design, rather than real differences based on data. Because we have used a range of models with different sets of inputs and outputs, our findings are consistent.

As regards average efficiency score across the models, only ASB and TSB have scores lower than 90%. The main reason for this appears to be the lower scores for ASB and TSB in models 5, 6 and 7. An examination of the inputs and outputs in these models indicates insufficient revenue generation (ASB) in proportion to the branch and staff numbers, asset base and fixed assets employed (excess capacity) and in

[6] Lest they become targets of takeovers or in market mergers

particular respect of TSB, the low level of non-interest income as the reasons for the observed inefficiency. Whilst these banks appear to have efficient cost structures it does not imply that there are no efficiency gains to be made. To focus on insufficient revenue generation, we ran model 1 with output orientation and the results[7] indicate insufficient revenue generation both in terms of net interest income and non-interest income for ASB. Over the three-year period from 2000 to 2002 both the banks have improved their scores, indicating improvements.

There is a further issue that arises with both ASB and TSB, relating to the ways in which our models have been specified. We have been looking for input minimization, and out inputs and outputs have generally been defined to shed light on banks' efforts to use minimum amounts of resources to achieve given levels of outputs. It is arguable, particularly in the case of ASB, however, that one of its objectives has been to achieve growth, but that we have not been assessing its performance fairly in that we have not included asset growth in our range of possible output variables. Having regard to DEA's origins in assessing the efficiency of non-profit organisations, there is no intrinsic reason why we could not have included it: it is just that asset growth has not usually been considered in as an objective in other banking studies, while it would also be an unusual objective in terms of standard microeconomic approaches to optimization.

A strong time trend effect is evident in models 10 and 11. In both the models, the efficiency scores tended to increase during the period of study reflecting an upward trend in the scores. When we look at the inputs and outputs of these models and note the asset growth in the New Zealand banking system, such a result should not be unexpected. The asset growth was achieved with minimal additional utilisation of physical resources, and the amounts of deposits and advances have increased together.

Note also that this is a different time series effect that that which was found by Tripe (2003). That effect was based on falling levels of interest expense (as an input), associated with reductions in the general level of interest rates. Interest rates have not

[7] Radial movements

shown the same variation over the period of this study, and thus only weak effects are evident in Models 1, 2 and 3, which have interest expense as an input.

The NBNZ emerges as the most efficient in the sample since its scores are consistently high over all the three years in all but one model. The lower score for NBNZ in model 3 seems to indicate higher staff expenses: such a result is not unexpected as the NBNZ has a higher level of staff expense per staff member than do the other banks (although it also has a higher level of assets per staff member). ASB's high staff expense may also account for its lower score in Model 3, but we can improve our understanding of this result by also looking at Models 7 (which has staff numbers as an input) and 8 (which has staff expense as an input). ASB shows as less efficient in Model 7, which suggests that the staff expense problem is primarily a staff numbers problem. Clearly DEA is sensitive to the choice of variables and provides specific information on where to start improving the efficiency of DMUs under scrutiny (Avkiran, 1999). In this case, by focusing on staff expenses, DEA provides specific information to the management as regards potential inefficiencies in staff expenses, although in the NBNZ's case, the bank may now wish to reduce staff expense, noting the efficiencies being demonstrated in other models.

The low score for 2000 for ANZ in model 10 suggests scope for rationalization of branches. The improvement in the bank's score in years 2001 and 2002 is consistent with the reduction in the number of ANZ's branches from 149 in 2000 to 143 in 2001. This is an interesting insight in view of the ANZ's recent suggestions that it needs to increase the number of its branches, despite figures suggesting that it has relatively lower assets per branch. The whole question of the adequacy of banks' branch networks is being challenged in any case by the entry of Kiwibank and Superbank, both of which have large branch networks via Postshops and supermarkets respectively.

TSB shows good performance in 11 out of the 14 models. The high efficiency scores of TSB compared to the five bigger banks indicate that scale is not necessarily

impacting on performance.[8] TSB is the only bank with major size difference relative to other banks in the sample and the lack of any clear efficiency disadvantage provides support for our decision to use the constant returns to scale model. The scores of other banks do not provide any evidence for scale economies. Tripe (2003) arrives at a similar conclusion in his study of trends in New Zealand bank efficiency over time. These results are consistent with the findings of Walker (1999) and Liu & Tripe (2002).

VI. Concluding remarks

The study has used fourteen different DEA models with different combinations of inputs and outputs to examine efficiency gains for six major banks in New Zealand over the period 2000-2002 and extends the results reported in Liu and Tripe (2002). Major findings from this study are as follows. New Zealand banks have become more efficient, in general over the period 2000 to 2002 and the overall average efficiency of the banks is quite high. Another important finding has been that New Zealand banking industry is fairly competitive. The NBNZ emerges as highly efficient in all three years while the results of TSB indicate that scale of operations is not necessarily a factor for improved efficiency.

Our analysis has also demonstrated ways in which DEA results can be used to gain an enhanced understanding of what is driving bank efficiency and hence bank performance. The results we have been able to derive from this study (and we have not sought to interpret all the available results) can generate a significantly enhanced understanding relative to a simple comparison of cost to income ratios. The relative efficiency scores generated by DEA have an advantage because they can take account of multiple inputs and multiple outputs.

Further studies in New Zealand may entail panel data using the Malmquist index (Worthington, 1999; Avkiran 2000) and attempting some cross country analysis to better understand the relative performance of the New Zealand banking system. Also, in view of the strong relationship that exists between the New Zealand and

[8] The lower scores of TSB Bank in models 5, 6, and 7 would appear to reflect the different variables used and can thus be attributed to model design.

Australian banking sectors, it would be interesting to study the comparative efficiencies. There may also be merit in applying parametric techniques for efficiency measurement (for example SFA) of New Zealand banks' data set and compare the results with non parametric approaches like DEA.

References:

Avkiran, N. K. (1999). The evidence on efficiency gains: the role of mergers and benefits to the public. *Journal of Banking and Finance*. 23. 991-1013.

Avkiran, N.K. (2000). Rising productivity of Australian trading banks under deregulation. 1986-1995. *Journal of Economics and Finance*. 24(2). 122-140.

Bauer, P.W.; Berger, A.N.; Ferrier, G.D. & Humphrey, D.B. (1998). Consistency conditions for regulatory analysis of financial institutions: a comparison of frontier efficiency methods. *Journal of Economics and Business*. 50. 85-114.

Berger, A. N. & Humphrey, D. B. (1992). Measurement and efficiency issues in commercial banking. Chapter 7 in Griliches, Z.; Berndt, E. R.; Bresnahan, T. F. & Manser, M., *Output Measurement in the Service Sectors.* Chicago: University of Chicago Press.

Berger, A.N. & Humphrey, D.B. (1997). Efficiency of financial institutions: international survey and directions for future research. *European Journal of Operational Research.* 98. 175-212.

Berger, A.N., Hunter, W.C., and Timme, S.G. (1993). The efficiency of financial institutions: a review and preview of research past, present and future. *Journal of Banking and Finance.* 17. 221-249.

Berger, A. N & Mester, L. J. (1997). Inside the black box: what explains differences in the efficiency of financial institutions? *Journal of Banking and Finance.* 21. 895-947.

Charnes, A., Cooper, W.W., Rhodes, E., (1978). Measuring efficiency of decision making units. *European Journal of Operational Research*. 2. 429-444.

Coelli, T., (1996). A Guide to DEAP Version 2.1, A Data Envelopment Analysis (Computer) Program, *CEPA Working paper* 96/08.

Cooper, W. W.; Seiford, L. M. & Tone, K. (2000). *Data Envelopment Analysis.* Boston: Kluwer Academic Publishers.

Dyson, R. G.; Allen, R.; Camanho, A. S.; Podinovski, V. V.; Sarrico, C. S. & Shale, E. A. (2001). Pitfalls and protocols in DEA. *European Journal of Operational Research.* 132. 245-259.

Farrell, M.J., (1957). The measurement of productive efficiency. *Journal of Royal Statistical Society.* 120 Sec A. 253-281.

Ferrier, G., Lovell, C.A.K., (1990). Measuring cost efficiency in banking. Econometric and linear programming evidence. *Journal of Econometrics.* 46. 229-245.

Fried, H.O., Lovell, C.A.K., Eackaut, P.V., (1993). Evaluating the performance of US credit unions. *Journal of Banking and Finance.* 17. 251-265.

KPMG, (Various). *New Zealand Financial Institutions Performance Survey*. Wellington: KPMG.

Liu, B & Tripe D.W.L. (2002). New Zealand bank mergers and efficiency gains. *Journal of Asia-Pacific Business.* 4 (4). 61-81

McAllister, P.H., McManus, D., (1993). Resolving the scale efficiency puzzle in banking. *Journal of Banking and Finance.* 17, 389-405.

Mester, L.J. (1987, January/February). Efficient production of financial services: scale and scope economies. *Federal Reserve Bank of Philadelphia Business Review*. 15-25.

Resti, A. (1997). Evaluating the cost-efficiency of the Italian banking system: What can be learned from the joint application of parametric and non-parametric techniques. *Journal of Banking and Finance.* 21. 221-250.

Sathye, M. (2001). X-efficiency in Australian banking: an empirical investigation. *Journal of Banking and Finance*. 25. 613-630.

Seiford, L.M., Thrall, R.M. (1990) Recent developments in DEA. The mathematical programming approach to frontier analysis. *Journal of Econometrics.* 46. 7-38.

Sherman, D., Gold, F. (1985). Branch operating efficiency: Evaluation with Data Envelopment Analysis. *Journal of Banking and Finance.* 9. 297-315.

Tripe D.W.L. (1998). *Cost to income ratios in Australasian banking*. Available at http://centre-banking-studies.massey.ac.nz/research_prog.asp.

Tripe, D.W.L. (2003). Trends in New Zealand bank efficiency over time. *Applied Econometrics and International Development.* 3 (1).

Valentine, T.J. & Williamson, P.J. (1982). A note on economies of scale in Australian banking. *In Australian Financial System Inquiry, Commissioned Studies and Selected Papers*. Volume 1. 703-709.

Walker, G. (1998, March). Economies of scale in Australian banks 1978-1990. *Australian Economic Papers.* 37 (1). 71-87.

Walker, G. (1999). Cost structures and efficiency in banking. Chapter 9 in T.Valentine and G. Ford (eds), *Readings in Financial Institution Management*. Sydney:Allen & Unwin. Pp 115-129.

Worthington, A.C. (1999). Malmquist indices of productivity change in Australian financial services. *Journal of International Financial Markets, Institutions and Money.* 9. 303-320.

TABLE 2

SUMMARY TABLE OF EFFICIENCY SCORES

DMUS/MODELS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	AVG
ASB1	0.806	0.950	0.758	0.877	0.757	0.764	0.764	0.877	0.953	0.745	0.813	0.953	0.923	0.923	0.847
BNZ1	0.887	0.795	0.867	1.000	1.000	1.000	1.000	1.000	0.877	0.731	0.853	0.877	0.877	0.880	0.903
WESTPAC1	0.977	0.902	0.977	0.918	0.853	1.000	0.901	0.950	0.892	0.725	0.736	0.892	0.966	0.966	0.904
NBNZ1	0.948	0.933	0.780	0.968	1.000	0.986	0.986	0.986	0.924	0.786	0.845	0.924	0.924	0.924	0.922
ANZ1	1.000	0.834	1.000	1.000	0.957	1.000	1.000	1.000	0.885	0.733	0.838	0.885	0.885	0.885	0.922
TSB1	1.000	1.000	1.000	0.671	0.498	0.543	0.490	0.866	1.000	0.647	0.817	1.000	0.986	0.986	0.822
ASB2	0.812	0.891	0.772	0.886	0.865	0.731	0.779	0.883	0.939	0.890	0.932	0.939	0.899	0.882	0.864
BNZ2	0.890	0.845	0.873	0.981	0.988	0.918	0.905	0.952	0.895	0.836	0.906	0.895	0.895	0.874	0.904
WESTPAC2	0.938	0.960	0.971	1.000	0.883	0.869	0.810	1.000	1.000	0.954	0.954	1.000	1.000	0.949	0.949
NBNZ2	0.945	1.000	0.763	1.000	1.000	1.000	1.000	1.000	0.962	0.923	0.963	0.962	0.962	0.976	0.961
ANZ2	1.000	0.966	1.000	1.000	0.967	0.986	1.000	0.998	0.890	0.870	0.958	0.890	0.920	0.952	0.957
TSB2	0.958	0.937	0.939	0.683	0.650	0.552	0.577	0.886	1.000	0.848	0.969	1.000	1.000	1.000	0.857
ASB3	0.867	0.967	0.792	0.932	0.814	0.773	0.876	0.954	0.920	0.977	1.000	0.920	0.916	0.876	0.899
BNZ3	1.000	0.952	0.978	1.000	1.000	0.959	0.962	0.995	0.965	1.000	1.000	0.965	0.958	0.947	0.977
WESTPAC3	1.000	1.000	1.000	0.994	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
NBNZ3	1.000	1.000	0.794	0.969	1.000	1.000	1.000	1.000	0.980	1.000	1.000	0.980	0.980	1.000	0.979
ANZ3	0.865	1.000	0.823	0.844	0.847	1.000	1.000	1.000	0.900	0.909	0.979	0.900	0.957	1.000	0.930
TSB3	1.000	1.000	1.000	0.838	0.619	0.513	0.574	0.994	1.000	0.900	1.000	1.000	1.000	0.950	0.885
MEAN	**0.939**	**0.941**	**0.894**	**0.920**	**0.872**	**0.866**	**0.868**	**0.963**	**0.943**	**0.860**	**0.920**	**0.943**	**0.947**	**0.943**	

TABLE 3

SUMMARY TABLE OF MINIMUM,MAXIMUM,MEAN & STANDARD DEVIATION OF TECHNICAL EFFICIENCIES

DMUS	1	2	3	4	5	6	7	8	9	10	11	12	13	14
MIN	0.806	0.795	0.758	0.671	0.498	0.513	0.490	0.866	0.877	0.647	0.736	0.877	0.877	0.874
MAX	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MEAN	0.939	0.941	0.894	0.920	0.872	0.866	0.868	0.963	0.943	0.860	0.920	0.943	0.947	0.943
STDDEV	0.068	0.064	0.099	0.105	0.153	0.177	0.169	0.050	0.046	0.110	0.082	0.046	0.043	0.047

TABLE 4

AVERAGES

DMUS	1	2	3	4	5	6	7	8	9	10	11	12	13	14
ASB														
ASB1	0.806	0.950	0.758	0.877	0.757	0.764	0.764	0.877	0.953	0.745	0.813	0.953	0.923	0.923
ASB2	0.812	0.891	0.772	0.886	0.865	0.731	0.779	0.883	0.939	0.890	0.932	0.939	0.899	0.882
ASB3	0.867	0.967	0.792	0.932	0.814	0.773	0.876	0.954	0.920	0.977	1.000	0.920	0.916	0.876
AVERAGE	**0.828**	**0.936**	**0.774**	**0.898**	**0.812**	**0.812**	**0.806**	**0.905**	**0.937**	**0.871**	**0.915**	**0.937**	**0.913**	**0.894**
ALLBKMEAN	**0.939**	**0.941**	**0.894**	**0.920**	**0.872**	**0.866**	**0.868**	**0.963**	**0.943**	**0.860**	**0.920**	**0.943**	**0.947**	**0.943**
BNZ														
BNZ1	0.887	0.795	0.867	1.000	1.000	1.000	1.000	1.000	0.877	0.731	0.853	0.877	0.877	0.880
BNZ2	0.890	0.845	0.873	0.981	0.988	0.918	0.905	0.952	0.895	0.836	0.906	0.895	0.895	0.874
BNZ3	1.000	0.952	0.978	1.000	1.000	0.959	0.962	0.995	0.965	1.000	1.000	0.965	0.958	0.947
AVERAGE	**0.926**	**0.864**	**0.906**	**0.994**	**0.996**	**0.959**	**0.956**	**0.982**	**0.912**	**0.856**	**0.920**	**0.912**	**0.910**	**0.900**
ALLBKMEAN	**0.939**	**0.941**	**0.894**	**0.920**	**0.872**	**0.866**	**0.868**	**0.963**	**0.943**	**0.860**	**0.920**	**0.943**	**0.947**	**0.943**
WESTPAC														
WESTPAC1	0.977	0.902	0.977	0.918	0.853	1.000	0.901	0.950	0.892	0.725	0.736	0.892	0.966	0.966
WESTPAC2	0.938	0.960	0.971	1.000	0.883	0.869	0.810	1.000	1.000	0.954	0.954	1.000	1.000	0.949
WESTPAC3	1.000	1.000	1.000	0.994	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
AVERAGE	**0.972**	**0.954**	**0.983**	**0.971**	**0.912**	**0.956**	**0.904**	**0.983**	**0.964**	**0.893**	**0.897**	**0.964**	**0.989**	**0.972**
ALLBKMEAN	**0.939**	**0.941**	**0.894**	**0.920**	**0.872**	**0.866**	**0.868**	**0.963**	**0.943**	**0.860**	**0.920**	**0.943**	**0.947**	**0.943**

DMUS	1	2	3	4	5	6	7	8	9	10	11	12	13	14
NBNZ														
NBNZ1	0.948	0.933	0.780	0.968	1.000	0.986	0.986	0.986	0.924	0.786	0.845	0.924	0.924	0.924
NBNZ2	0.945	1.000	0.763	1.000	1.000	1.000	1.000	1.000	0.962	0.923	0.963	0.962	0.962	0.976
NBNZ3	1.000	1.000	0.794	0.969	1.000	1.000	1.000	1.000	0.980	1.000	1.000	0.980	0.980	1.000
AVERAGE	**0.964**	**0.978**	**0.779**	**0.979**	**1.000**	**0.995**	**0.995**	**0.995**	**0.955**	**0.903**	**0.936**	**0.955**	**0.955**	**0.967**
ALLBKMEAN	**0.939**	**0.941**	**0.894**	**0.920**	**0.872**	**0.866**	**0.868**	**0.963**	**0.943**	**0.860**	**0.920**	**0.943**	**0.947**	**0.943**
ANZ														
ANZ1	1.000	0.834	1.000	1.000	0.957	1.000	1.000	1.000	0.885	0.733	0.838	0.885	0.885	0.885
ANZ2	1.000	0.966	1.000	1.000	0.967	0.986	1.000	0.998	0.890	0.870	0.958	0.890	0.920	0.952
ANZ3	0.865	1.000	0.823	0.844	0.847	1.000	1.000	1.000	0.900	0.909	0.979	0.900	0.957	1.000
AVERAGE	**0.955**	**0.933**	**0.941**	**0.948**	**0.924**	**0.995**	**1.000**	**0.999**	**0.892**	**0.837**	**0.925**	**0.892**	**0.921**	**0.946**
ALLBKMEAN	**0.939**	**0.941**	**0.894**	**0.920**	**0.872**	**0.866**	**0.868**	**0.963**	**0.943**	**0.860**	**0.920**	**0.943**	**0.947**	**0.943**
TSB														
TSB1	1.000	1.000	1.000	0.671	0.498	0.543	0.490	0.866	1.000	0.647	0.817	1.000	0.986	0.986
TSB2	0.958	0.937	0.939	0.683	0.650	0.552	0.577	0.886	1.000	0.848	0.969	1.000	1.000	1.000
TSB3	1.000	1.000	1.000	0.838	0.619	0.513	0.574	0.994	1.000	0.900	1.000	1.000	1.000	0.950
AVERAGE	**0.986**	**0.979**	**0.980**	**0.731**	**0.589**	**0.536**	**0.547**	**0.915**	**1.000**	**0.798**	**0.929**	**1.000**	**0.995**	**0.979**
ALLBKMEAN	**0.939**	**0.941**	**0.894**	**0.920**	**0.872**	**0.866**	**0.868**	**0.963**	**0.943**	**0.860**	**0.920**	**0.943**	**0.947**	**0.943**

TABLE 5

SUMMARY TABLE OF AVERAGE SCORES OF TECHNICAL EFFICIENCY

DMUS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	AVG
ASB	0.828	0.936	0.774	0.898	0.812	0.812	0.806	0.905	0.937	0.871	0.915	0.937	0.913	0.894	0.874
BNZ	0.926	0.864	0.906	0.994	0.996	0.959	0.956	0.982	0.912	0.856	0.920	0.912	0.910	0.900	0.928
WESTPAC	0.972	0.954	0.983	0.971	0.912	0.956	0.904	0.983	0.964	0.893	0.897	0.964	0.989	0.972	0.951
NBNZ	0.964	0.978	0.779	0.979	1.000	0.995	0.995	0.995	0.955	0.903	0.936	0.955	0.955	0.967	0.954
ANZ	0.955	0.933	0.941	0.948	0.924	0.995	1.000	0.999	0.892	0.837	0.925	0.892	0.921	0.946	0.936
TSB	0.986	0.979	0.980	0.731	0.589	0.536	0.547	0.915	1.000	0.798	0.929	1.000	0.995	0.979	0.855

TABLE 6 SUMMARY TABLE OF EFFICIENCY SCORES

DMUS	1	2	3	4	5	6	7	8	9	12	13	14	Avg
ASB1	0.806	0.950	0.758	0.877	0.757	0.764	0.764	0.877	0.953	0.953	0.923	0.923	0.859
BNZ1	0.887	0.795	0.867	1.000	1.000	1.000	1.000	1.000	0.877	0.877	0.877	0.880	0.922
WESTPAC1	0.977	0.902	0.977	0.918	0.853	1.000	0.901	0.950	0.892	0.892	0.966	0.966	0.933
NBNZ1	0.948	0.933	0.780	0.968	1.000	0.986	0.986	0.986	0.924	0.924	0.924	0.924	0.940
ANZ1	1.000	0.834	1.000	1.000	0.957	1.000	1.000	1.000	0.885	0.885	0.885	0.885	0.944
TSB1	1.000	1.000	1.000	0.671	0.498	0.543	0.490	0.866	1.000	1.000	0.986	0.986	0.837
ASB2	0.812	0.891	0.772	0.886	0.865	0.731	0.779	0.883	0.939	0.939	0.899	0.882	0.857
BNZ2	0.890	0.845	0.873	0.981	0.988	0.918	0.905	0.952	0.895	0.895	0.895	0.874	0.909
WESTPAC2	0.938	0.960	0.971	1.000	0.883	0.869	0.810	1.000	1.000	1.000	1.000	0.949	0.948
NBNZ2	0.945	1.000	0.763	1.000	1.000	1.000	1.000	1.000	0.962	0.962	0.962	0.976	0.964
ANZ2	1.000	0.966	1.000	1.000	0.967	0.986	1.000	0.998	0.890	0.890	0.920	0.952	0.964
TSB2	0.958	0.937	0.939	0.683	0.650	0.552	0.577	0.886	1.000	1.000	1.000	1.000	0.849
ASB3	0.867	0.967	0.792	0.932	0.814	0.773	0.876	0.954	0.920	0.920	0.916	0.876	0.884
BNZ3	1.000	0.952	0.978	1.000	1.000	0.959	0.962	0.995	0.965	0.965	0.958	0.947	0.973
WESTPAC3	1.000	1.000	1.000	0.994	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
NBNZ3	1.000	1.000	0.794	0.969	1.000	1.000	1.000	1.000	0.980	0.980	0.980	1.000	0.975
ANZ3	0.865	1.000	0.823	0.844	0.847	1.000	1.000	1.000	0.900	0.900	0.957	1.000	0.928
TSB3	1.000	1.000	1.000	0.838	0.619	0.513	0.574	0.994	1.000	1.000	1.000	0.950	0.874
	MEAN	**0.939**	**0.941**	**0.894**	**0.920**	**0.872**	**0.866**	**0.868**	**0.963**	**0.943**	**0.943**	**0.947**	**0.943**