AN EXAMINATION OF NEW ZEALAND BANK EFFICIENCY

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Abstract:

This research explores the efficiency of the New Zealand banking system over the period 1996 to 2003 using Data Envelopment Analysis (DEA). DEA is used as a lack of data on prices and the relatively small cross-sections (because of the limited number of banks in the New Zealand market) pose difficulties for the use of parametric methods.

This is the first major research to make use of the data-set provided under the New Zealand banking disclosure regime, and the first major attempt at contrasting the relative efficiency of banks in Australia and New Zealand.

The research discusses the problems of analysis of efficiency in small banking markets and proposes a solution through use of panel data. Analysis on this basis highlights problems that arise from changing environmental conditions (specifically from changes in the general level of interest rates), but also produces a reasonably consistent ranking of the efficiency of New Zealand banks.

The research finds that equity is an important input to the study of bank efficiency, and that it is a cause of differences in relative efficiency between New Zealand and Australian banks.

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1. Introduction

1.1 Background

At an immediate impression, the structure of the New Zealand banking market at the beginning of 2005 differs somewhat from the perfectly competitive model. There is a small group of four banks (sharing five brands), which dominate the retail banking market. Because the banks' pricing of their products is inclined to be relatively close to each other, this commonly leads to allegations of monopolistic practice, that there is no real competition between the banks, and that the banks are able to price their products in ways that allow them to extract excessive profits from a public that lacks alternative channels to access financial services.

This issue is aggravated in the New Zealand context by the dominance of foreign, particularly Australian, ownership. As at 30 June 2004, 98.5% of New Zealand banks' assets were foreign owned, with 86.6% of banking system assets under Australian ownership. This is inclined to raise questions in the public mind as to whether the major Australian banks are using their dominance of the New Zealand market to charge excessive prices, and to deprive New Zealanders of easy access to low-cost and efficient financial services. This sort of perception is inclined to be encouraged by the relatively high profits being achieved by the Australian banks in their New Zealand businesses, whether these profits are measured by return on assets or return on equity.[1]

At the same time, banks in New Zealand, and some of the Australian-owned banks in particular, have put a lot of emphasis on their costs in recent years, and have sought to reduce these. Significant reductions have been achieved, both in terms of reduced cost to income ratios and reduced ratios of costs to assets. This has been accompanied by extensive branch closures, with the number of retail bank branches in New Zealand having reduced from 1,447 in 1995 to 832 by 2001. This has been another issue of concern to the wider public, who have been inclined to associate the reduction in the

[1] This is discussed further in Section 2.5 below.

scale of banks' branch networks with a general deterioration in customer service standards.

1.2 The problem

This listing of negative perceptions for the performance of the New Zealand banking system has not, in general, been tested in any empirical way, which means that a number of questions are left about the performance of the New Zealand banking system. If it is assumed that an efficient banking system is a good thing, there should be a public benefit in the banking system becoming more efficient. If the costs incurred in the overall operations of New Zealand banks have been reduced as they have sought to enhance their profitability, does this mean that the banks have become more efficient? Does the strong profit performance of the New Zealand banks mean that the banks are efficient? Are there any special issues that arise as a result of the high degree of foreign ownership of the New Zealand banking system?

1.3 Aim and objectives of this research

The aim of this research is already indicated in the listing of problems in the previous section, and in the dissertation's title: how efficient are New Zealand banks, and have they become more efficient over time? As efficiency is inclined to be a relative measure, this will also entail attempting some assessment of the efficiency of the major banks in Australia.

This research therefore looks at what efficiency is, at the different approaches that may be applied to its measurement, and at the problems that arise with these types of analysis. It reviews the New Zealand banking system in greater depth, to gain an understanding of how the current position has been reached, and to appreciate issues that arise with the data used to try and measure the banks' efficiency. It affirms the desirability of using a multivariate approach to measurement of bank efficiency, rather than merely relying on ratios. The analysis uses a number of different approaches, and the dissertation seeks to compare and contrast the results obtained.

1.4 The importance of this research

This research is important as the first major study of New Zealand bank efficiency, and also as the first major piece of research that has been undertaken making use of the data provided by New Zealand banks' disclosure regime. It is also the first major research to try to compare and contrast the relative performance of the Australian and New Zealand banking systems.

There are other ways in which this research should also make a contribution. The study of bank efficiency has led to relatively few points of agreement in relation to method and interpretation of results, and this dissertation seeks to outline some approaches that may be followed in small economies with relatively concentrated banking systems (and with relatively small number of banks in particular). It will also make suggestions for issues which have posed problems for other researchers in areas of bank efficiency, particularly in the use of Data Envelopment analysis, which is the method used for this research.

1.5 An outline of the dissertation

Because much of the dissertation reports on the analysis of quantitative data, it is written in the third person. Where the author's views are being reported, these are identified accordingly.

The rest of the dissertation is structured as follows. Chapter Two reviews the New Zealand banking system, and at how it has developed to its current situation. Chapter Three contains a discussion of the meaning of efficiency, and then reviews relevant previous approaches to researching it in financial institutions (and banks in particular). Chapter Four outlines the data that is used, primarily in respect of the New Zealand banking system, but also in respect of Australia, and sets out the individual studies that are undertaken in an attempt to answer the questions posed. Chapter Five reports the results obtained, and discusses these. Chapter Six concludes and provides some suggestions for areas where follow-up research might be undertaken in the future.

2. New Zealand and its banking system

One of the remarkable features of the New Zealand economy has been the extent of deregulation that has occurred, particularly since a change in government following the 1984 general election. Deregulation has occurred in many sections of the economy, with the changes in the financial sector being among the most noteworthy.[2] Significant changes were effected in monetary policy and the way in which it was implemented, but there were also changes in the activities financial institutions were permitted to undertake, and a consequent series of changes in the ways in which they have operated.

This dissertation focuses on one particular class of financial institutions, the banks, a group of firms within the financial sector which has grown substantially since 1984, and which now have a much more important role in the financial system.[3] A new system for bank registration came into effect in 1987, while further changes have included the adoption of what is regarded internationally as a new and innovative approach to the prudential supervision of banks. This is based on public disclosure, and the information it provides has contributed a major source of data for this research.

More or less contemporaneously with what was happening in New Zealand, a process of deregulation was also occurring in Australia, although the process started a little earlier in Australia than it did in New Zealand, and occurred at a rather less frenetic pace. Deregulation in Australia also impacted quite significantly on the banking sector, and there are some interesting parallels. This dissertation thus also has regard to the Australian market, the importance of which is highlighted by the fact that, as at 31 March 2003, 66.3% of New Zealand bank assets were under Australian ownership.[4] By 31 December 2003, following the acquisition of the (formerly British-

[2] See Evans et al (1996) for a review of the deregulation/economic reform process in New Zealand.
[3] This would seem to be particularly the case with loans – see Thorp & Ung (2000), Table 2 (p 20). No particular difference is evident in terms of the proportion of household financial assets held with deposit-taking institutions, at least up to 2000. Note, however, that today's five largest banking groups are identified as holding a significantly increased proportion of household financial assets.
[4] See Tripe & Matthews (2003) for a review of the international expansion into New Zealand and other markets undertaken by the major Australian banks.

owned) National Bank of New Zealand by the ANZ Banking Group Limited, the proportion of Australian ownership had increased to 86.4%.

The following sections of this Chapter look at aspects of the New Zealand financial system prior to deregulation, and at the changes that followed, through to the structure of the New Zealand banking system as at early 2003. This outline provides a background against which the research reported in this dissertation can be set, while also identifying and describing the main subjects for the research.

2.1 The situation prior to deregulation

The New Zealand banking system as it existed prior to 1984 was firmly segmented. Following the merger of two Australian banks with New Zealand operations (the Bank of New South Wales and the Commercial Bank of Australia) to form Westpac in 1982, there were four trading banks.[5] There were also savings banks, of three types, short-term money market dealers, merchant banks and building societies, with each group having its own defined role. In addition to these, there was a range of other institutions operating in the financial sector, some of which appeared to owe their role to restrictions placed on the operations of the classes of financial institutions reported above.

Over and above the strict segmentation of the New Zealand financial system there was a range of other regulatory controls that applied. There were direct controls on a range of their activities, and mandatory ratios applying to different classes of assets. There were strict limitations in the entry of new firms to the more controlled sectors (banking in particular), and limits on foreign ownership, although the trading banks were already mostly foreign owned, as they had been more or less ever since the Union Bank (a British overseas bank) had established a branch in Wellington in 1840.

The four trading banks that operated in 1984 were the ANZ Banking Group (New Zealand) Ltd (ANZ), Bank of New Zealand (BNZ), the National Bank of New

[5] These were the banks that provided services to both personal and business customers, and which operated the infrastructure for cheque clearance in the New Zealand economy.

Zealand Limited (NBNZ), and the Westpac Banking Corporation (Westpac). The ANZ was incorporated in New Zealand and had a New Zealand sharemarket listing, with approximately 25% of its shares owned by New Zealand investors, but the controlling shareholding was with its Australian parent bank.[6] The BNZ had been owned by the government since 1945, and was the government's transactional bank. The NBNZ had been originally constituted as a British overseas bank, but the remaining independent shareholding was purchased in the late 1960s to make the bank a wholly owned subsidiary of Lloyds Bank Ltd (Holmes, 1999). Westpac operated as a branch of its Australian parent bank, a publicly listed company on the Australian stock exchange.

A market controlled by four banks may commonly be assumed to be uncompetitive, although there is no necessity for that to be the case. In practice, however, competition between the banks in New Zealand was severely constrained. They operated together a jointly-owned computer system, Databank Systems Limited, which not only provided clearing for interbank transactions but which also provided account keeping and almost all other computing functions for the banks' New Zealand operations. Banks' interest rates on deposits and loans were subject to controls (most particularly during the years immediately prior to the 1984 election when these controls were part of a broader wage and price freeze), which limited banks' ability to compete against each other on price. Fixed ratio requirements and other controls, which tended to limit banks' access to wholesale funding, limited banks' ability to compete by mounting aggressive lending campaigns, and thus the major area of competition was inclined to be service. This was reflected most particularly in the extent of the banks' branch networks (Harper, 1986, pp 26-27; Harper & Karacaoglu, 1987, p 209).

Competition was also constrained by barriers to entry. At a regulatory level, entry of a new bank would have required an Act of Parliament, while at a practical, economic level, a new bank would have required a very substantial investment in the development of a branch network and technological infrastructure if it was to be able

[6] The bank had been pressed to float a portion of its New Zealand business in the late 1970s in response to a regulatory request: it had previously operated as a branch of its parent bank. The change of status is recorded by Deane et al (1983), p 31. The parent bank, Australia and New Zealand Banking Group Limited, was publicly listed on the Australian stock exchange.

to compete against existing participants.[7] Even if this investment were made, the new banks would be likely to be severely hampered in acquisition of customer business from existing market participants (as was found by new entrants to the Australian market following the issuance of new banking licences in 1985).[8]

The trading banks did have some advantages relative to other classes of financial institutions, however. They were the only institutions which could offer cheque accounts for businesses, and they also had a monopoly of foreign exchange dealing (up until August 1983). Nicholl & King (1985, p 237) note how profitable this was for the banks.

There were three classes of savings banks: the government-owned Post Office Savings Bank (POSB), which was part of the Post Office, the trustee savings banks and the private savings banks (of which there were four, one owned by each of the trading banks). Each of these classes of savings banks was covered by its own legislation, and there were different restrictions applying to each of them.

The POSB had an extensive nation-wide network through the Post Office, whereas the 12 trustee banks each had their regional focus and did not compete with each other (they also shared computer systems). The private savings banks were separately incorporated companies, although they generally operated as divisions of their parent banks and utilised parent bank infrastructure.

The POSB and trustee savings banks offered an extensive range of savings accounts and cheque accounts for the personal sector (they also dealt with non-profit organisations). Their lending was predominantly in residential mortgage loans, particularly after they were the beneficiaries of some liberalisation in the mid 1970s. The private savings banks tended to be restricted to passbook savings, but as Nicholl and King (1985, p 185) point out, other services were available to private savings banks' customers through the parent trading bank. All the savings banks tended to

[7] This was before the days when a viable E-banking option could be offered. There is also an argument that existing banks' branch networks might have constituted a barrier to entry for new participants. See Evanoff (1988). This is also consistent with the finding of To & Tripe (2002) that foreign banks with a long-standing presence in the New Zealand market performed more successfully.
[8] See Ferguson (1990), Hogan (1991).

have quite high proportions of their assets invested in government securities, while their deposits were guaranteed (Grimes, 1998, p 295).

The official short-term money market dealers were a category of institution that existed largely because of regulation, and which did not survive the removal of the regulatory boundaries which had protected them. They were distinguished from the trading banks by being allowed to pay interest on deposits for periods of less than 30 days, while also enjoying the benefit of access to the Reserve Bank as lender of last resort. The quid pro quo for this was being quite severely restricted in the assets in which they could invest (Nicholl & King, 1985, p 188).

The merchant banking sector comprised the unofficial short-term money market, although the merchant banks undertook a range of other activities as well. A number of the merchant banks obtained foreign exchange dealing licences when these were liberalised in August 1983. The merchant banks often represented the corporate business activities of finance companies, which played an important role in New Zealand credit markets through their hire purchase and other instalment financing activities.[9]

New Zealand had originally had two types of building societies, permanent and terminating, but legislation in 1981 prohibited the sale of further terminating shares. Following this, which stimulated some rationalisation in the sector, the number of building societies had shrunk to 33 by 1983, although 66% of the sector's assets were in the hands of just two mutually-owned societies, the United and Countrywide Building Societies (Nicholl & King, 1985, pp 206-207). In 1982, 69.9% of the sector's assets were in mortgage loans, mainly secured over residential property (Nicholl & King, 1985, p 209).

In addition to the classes of financial institutions described above, there were also some specialist government-owned institutions. The Housing Corporation of New Zealand specialised in housing lending, with a particular concentration on first-home buyers and others who might otherwise have difficulty in purchasing accommodation.

[9] As Grimes (1998, p 296) notes, the development of finance companies had been assisted by regulatory controls on the activities of other classes of financial institutions.

The Rural Banking and Finance Corporation (Rural Bank) played a similar role in supporting farming, primary industry and related service industries. The Development Finance Corporation (DFC) targeted its activities at new and expanding industries, particularly those with an export or regional development focus (Nicholl & King, 1985, pp 221-222).

There were some significant consequences of the restrictions imposed on the operations of the institutions listed above. In particular, interest rate restrictions on commercial lending were circumvented by use of the commercial bill market. Would-be borrowers would issue a commercial bill, which they would then get discounted, with the discount rate not being classed as a controlled interest rate.[10] Investors could buy commercial bills and earn a non-taxable capital gain by holding them to maturity.

Restrictions on housing lending were surmounted in a different way, using solicitors' nominee companies. Borrowers would typically be able to obtain advances secured by a first mortgage, with the funding provided by the nominee company, which would have a pool of investors who wanted to earn higher returns than were readily available from the banks (and until 1982, the interest rates were uncontrolled).[11]

The controls applying to the financial system were identified as having a number of negative consequences. Money and capital markets were perceived as underdeveloped, which made it difficult for both businesses and households to satisfy their credit and investment needs (Harper, 1986, p 28). Financial institutions' costs and margins were perceived as higher than they would have been if markets were more free, while the uneven application of monetary policy through quantitative controls meant that, for example, finance companies gained market share, despite being relatively high-cost institutions (Harper, 1986, pp 29-30). The question then arose as to how deregulation might assist in overcoming these negative effects.

[10] This occurred particularly during the period of interest rate restrictions associated with the wage and price freeze prior to the 1984 general election. The commercial bill market had originally been developed by the merchant banks in the 1970s, as it provided a vehicle for them to fund their lending.
[11] Thorp & Ung (2000, p 22) suggest that the solicitors' market had funded more than a third of total housing loans at its height in the early 1970s, but by 1984 the share of solicitors' loans in household financial liabilities was 17% (p 20).

2.2 The transformation of the banking sector

When the new Labour government was elected in July 1984, it found itself facing a financial crisis hinging on the value of the New Zealand dollar. Dealing with this issue required attention to a range of other issues as well. Although the initial focus of these was on monetary and exchange rate policy, a number of the changes had operational impacts on banks and other financial institutions, in terms of increasing their opportunities to compete against each other, and in providing them with new challenges in terms of servicing their customer base.

Thus, over the following months, interest rate restrictions and limitations on offshore borrowing were removed, as were compulsory ratios applying to financial institutions' balance sheets. The New Zealand dollar was floated, and the restrictions on the foreign ownership of financial institutions were abolished. In late 1985 the Reserve Bank announced policies which would provide for the entry of new banks to the New Zealand market.[12] The banking market was thus liberalised both in terms of the activities that banks could undertake and in terms of the number of banks.[13]

The announcement that new banks would be allowed into the New Zealand market became the Reserve Bank of New Zealand Amendment Act 1986, which came into effect on 1 April 1987. The key to this was a system of bank registration, with the four trading banks reclassified as registered banks as at 1 April 1987. Applications were opened for other institutions to seek registration, and, as of 22 July 1987, a further seven institutions were granted registration. These were Barclays New Zealand Limited (Barclays), Broadbank Corporation (Broadbank), CIBC New Zealand Limited (CIBC), Citibank NA (Citibank), the Hong Kong and Shanghai Banking Corporation (HSBC), Indosuez New Zealand Limited (Indosuez), Macquarie Bank Limited (Macquarie), and NZI Financial Corporation (which became known in due course as NZI Bank).[14]

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[12] For a full chronology, see Harper (1986), pp 40-43.

[13] One of the principles underpinning this approach was the theory of contestable markets, which implied that market participants would be obliged to act in a competitively optimal and efficient fashion (Doughty, 1986, p 113).

[14] This detail and a significant portion of the detail that follows derive from the Reserve Bank of New Zealand's "List of registered banks in New Zealand – past and present", available at http://www.rbnz.govt.nz/banking/nzbanks/0029134.html#TopOfPage.

Except for CIBC (which was a subsidiary of the Canadian Imperial Bank of Commerce, one of the big five Canadian banks), all of these had some history of participation in New Zealand financial markets.[15] Barclays had had a merchant banking operation through New Zealand United Corporation. Citibank had entered New Zealand with a merchant banking authority during the early 1980s, as had HSBC (operating as Wardleys). Indosuez had also had a merchant banking operation, with outside shareholders as had been required under the rules limiting institutions to a maximum of 70% foreign ownership.

NZI Financial Corporation was a long-established merchant bank, also with significant finance company activity, which was part of the New Zealand Insurance group, then one of New Zealand's major companies and listed on the New Zealand stock exchange. It was the only one of the new banks that was not part of a major international banking group.

Broadbank was also a long-established finance company and merchant banking group, which had been owned by the New Zealand conglomerate Fletcher Challenge until 1985, when it was sold to the Government Life Insurance Office. They, in turn, on sold 74% of it to the National Australia Bank group in early 1997. Broadbank Corporation Limited thus changed it name to National Australia Bank (NZ) Ltd (NAB(NZ)) in December 1987, and this became the New Zealand vehicle for the National Australia Bank group (NAB, which was a major Australian bank, listed on the Australian stock exchange).

Other institutions followed in successfully obtaining New Zealand banking registration. The Countrywide Building Society enlisted some outside investors and then obtained registration as Countrywide Banking Corporation in December 1987.[16] Security Pacific New Zealand Limited (Security Pacific), part of the Los Angeles based Security Pacific Bank, and which had been a shareholder in a New Zealand merchant bank, was also registered in December 1987. Bankers Trust obtained registration as BT New Zealand (Holdings) Ltd (BT) in June 1988.

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[15] Nicholl & Smith (1985) report some details on the previously existing merchant banks and foreign exchange dealers on pages 191 (Table 3.12) and 236 (Table 3.39) respectively.

[16] This was associated with deregulation of the building societies – see Spencer & Carey (1988, pp 11-12).

The forms in which these institutions were registered reflect a difference between the New Zealand and Australian approaches to the registration of new banks. In Australia, between World War II and 1985, foreign banks had only been allowed to operate as money market corporations: in 1985 an initial limit was imposed of 16 new foreign commercial banks, and one of the criteria for approval related to their potential contribution to Australia. New banks in Australia were also required to be separately incorporated, and many of them formed joint ventures with local participants, such as those between the Royal Bank of Canada and National Mutual, and between Chase Manhattan Bank and AMP. No such restrictions applied in New Zealand, although this was not perhaps clear at the time applications were being made. Thus it was perceived that CIBC, and perhaps also Security Pacific, had sought registration in New Zealand because of their failure to obtain registration in Australia. Many of the new banks were also established as subsidiaries of their parent banks: as they came up against the disadvantages of subsidiary status in terms of name recognition and access to funding,[17] many of the new entrants converted to branches of their parent banks.

Following the opening up of registration, changes were also occurring in the savings bank sector. As restrictions were removed, the separate existence of the private savings banks could no longer be justified, and these began to be reabsorbed into the operations of their parent banks.[18] The trustee savings banks began a process of consolidation and unification, although the Taranaki Savings Bank (now TSB Bank Limited, or TSB) preferred to remain separate, and achieved registration in its own right in June 1989. On 1 July 1986, the 11 remaining trustee banks announced the formation of Trusteebank Holdings Limited, which was to take over the functions of the Trustee Banks Association of New Zealand, and provide the basis for a new, more unified structure. This entity became Trust Bank New Zealand Limited on 30 September 1988 (Burns, 1989, p 169). Government restrictions were relaxed to allow the banks to engage in a broader range of activities (Carew, 1987, p 44). Trust Bank New Zealand Limited (Trust Bank) and its member banks were registered in December 1989.

[17] Some of the new entrants sought to overcome this disadvantage by obtaining formal letters of guarantee from their parent banks, which might be used to support a Trust Deed.
[18] This process was finally completed in 1993/94 (Thorp & Ung, 2000, p 32).

While that process was occurring, however, the largest of the banks, the Auckland Savings Bank (now ASB Bank Limited, or ASB), decided to withdraw from the path being followed by the other trustee banks, and it was followed in this by the Westland Savings Bank (Westland Bank). In early 1989, the community trust that (by now) owned ASB sold 75% of the bank to the Commonwealth Bank of Australia (CBA).[19] The ASB was thus able to accelerate its path towards registration, which it obtained in May 1989, with Westland Bank (which had been the smallest of the trustee savings banks, and which depended on ASB for a number of services) following in March 1990.

The operations of the POSB had initially been totally integrated with those of the Post Office, but when the Post Office was corporatised, it was split into three state-owned enterprises, New Zealand Post, Telecom, and PostBank (representing the banking operations). The government identified PostBank as able to be privatised, and it was purchased by ANZ in late 1988. PostBank obtained registered bank status in August 1989, although the ANZ continued to run it as a separate bank for a number of years after that.

A number of other institutions also obtained banking registration, generally with the objective of supporting other financial services businesses. The Australian conglomerate Elders was the ultimate parent company of Elderbank Limited (Elderbank), which obtained initial registration in March 1989. Australian life insurer National Mutual was the parent company for National Mutual Bank New Zealand Limited (National Mutual Bank), which was originally registered in June 1989. The specialist rural lender, Primary Industry Bank of Australia Limited (PIBA) obtained registration in May 1989. The Rural Bank, which had by then been sold by the government to Fletcher Challenge, obtained registration in August 1990. The United Building Society also converted to bank status (becoming known as United Bank), obtaining registration in June 1990, following its acquisition by the State Bank of South Australia (Sykes, 1996, p 505).

[19] The CBA was one of the four major full-service banks in Australia (alongside ANZ, NAB and Westpac), although it was at that time still wholly owned by the Australian government. Its entry to the New Zealand market meant that all four of the Australian major banks then had substantial operations in New Zealand.

With BNZ Finance (a finance company majority owned by the BNZ) obtaining registration in January 1991, most of the finance company sector was then part of registered banking groups. With the broader powers to engage in a wider range of activities now available to the banks, there was less of a role for separate stand-alone finance companies, although these institutions started to again find a distinct specialist role towards the end of the 1990s.[20]

Not only was registration easier than had been expected: getting out of the New Zealand market was also relatively easy. The first to leave was Security Pacific, whose business in New Zealand had been relatively small in any case, but whose departure was also influenced by the parent bank's problems in attempting to build a global wholesale banking business. It sold its business to the State Bank of South Australia, which had gained registration in December 1988. CIBC did not remain particularly long in New Zealand either, with registration being relinquished in July 1989.

The number of registered banks peaked in 1990 and 1991, and from that time on there were further withdrawals. Elderbank withdrew from the New Zealand market in August 1990 as its parent conglomerate came under pressure at home. National Mutual Bank relinquished its licence in December 1990, again in response to financial pressures on its parent. Such finance company business as National Mutual had in New Zealand was sold to the ANZ's finance company, UDC.[21] Macquarie Bank found that it gained no particular advantage from being a registered bank, and relinquished its registration in January 1991, although it has continued to operate in New Zealand since that time. NZI Bank had been badly affected by the 1987 stock market crash and its aftermath: it ran its business down and relinquished registration in February 1992. The State Bank of South Australia also ran into trouble in its home market, and it finally relinquished its New Zealand banking licence in July 1994.

Mergers and acquisitions also had their impact in reducing the numbers of registered banks. Thus PostBank was absorbed by the ANZ, Westland Bank by the ASB, the

[20] See Thorp (2003) for a more extensive discussion.
[21] It had been proposed that National Mutual's financial weakness would have been remedied by a merger with the ANZ, but permission for this was denied by the Australian Federal Treasurer, thus giving rise to the "six pillars" policy.

Rural Bank by the National Bank, NAB(NZ) by the BNZ (reflecting the acquisition of the BNZ by the NAB), and United Bank by Countrywide. This last acquisition reflected the problems of United Bank's parent, the State Bank of South Australia.

The absorption of the BNZ into the NAB group arguably reflected the ill preparedness of such New Zealand-owned financial institutions for the deregulated environment they now faced. The BNZ incurred substantial lending losses in the aftermath of the 1987 sharemarket crash, first in New Zealand, and then in Australia. This forced the government to effectively bail the bank out twice, despite its having been only partly government owned since a partial float in 1987. The government sold its shareholding in the bank to the NAB in 1992, and the NAB then succeeded in buying up the remaining minority shareholdings.

Another New Zealand owned entity which had wanted to become a bank, DFC, had failed in October 1989, a victim of problems in its commercial and corporate lending, many of which were associated with the 1987 stock market crash.

No new banks were registered between January 1991 and the end of 1995: the New Zealand banking sector was consolidating and settling down after the first rush of enthusiasm when the market was first opened up to new applicants. As of the end of 1995, there were 15 banks registered, compared with 22 at the end of 1990. Even though seven of those 15 banks had ceased to be registered by the end of 2003, the New Zealand banking system at the beginning of 1996 looked a lot more stable, with most of the excesses of the 1980s removed from bank balance sheets (although it was not until September 1996 that the BNZ's levels of impaired assets fell to levels in line with those of other banks).

At the beginning of April 1987, two of the four banks were Australian owned, one was British owned, and one was New Zealand owned. Some of the new banks to enter the market were or had been New Zealand owned entities, but by the end of 1995, only two banks remained in New Zealand ownership: TSB and Trust Bank New Zealand. New Zealand owned NZI Bank had entered the market and failed. ASB, Countrywide Bank and United Bank had acquired foreign shareholders prior to conversion to bank status. The financing of Countrywide's acquisition of United Bank

obliged it to become wholly foreign-owned. PostBank had been owned by the ANZ before it even gained registration as a bank. The Rural Bank was owned by New Zealand conglomerate Fletcher Challenge when it was registered, but it was later acquired by the United Kingdom owned NBNZ.

A number of the Australian entrants to the New Zealand market had also been and gone, with PIBA, which had been Australian owned, sold to the (Netherlands-owned) Rabobank group in late 1994. Elderbank, National Mutual Bank and the State Bank of South Australia had all otherwise been forced to contract as a result of pressures on their parent companies.

At the beginning of 1996, therefore, only 2 out of 15 banks were New Zealand owned, and these 2 banks accounted for 10.12% of the assets of the New Zealand banking system as at 31 March 1996. The beginning of 1996 also saw the introduction of a new system of banking supervision, based on quarterly public disclosure by the banks. This has generated significant quantities of information on the New Zealand banking system, and these data provide a basis for the research reported in this dissertation.

2.3 1996 and since

Another way of looking at the New Zealand banking market at the beginning of 1996 is to look at the activities the banks were undertaking, and at their relative significance in the market. Of the 15 banks that were registered, eight undertook significant retail banking business, with a collective market share of 92.12% of total assets. This group was still dominated by the four original trading banks, which had a combined market share of 67.89% of total assets, and which also undertook significant amounts of corporate and commercial banking business. A further two banks were specialists (PIBA and BNZ Finance). Of the other five banks, two (Citibank and HSBC) had a small amount of retail business, although they were primarily concentrated on the corporate market. Barclays and Indosuez were also focused on the corporate market, although Barclays also undertook some sharebroking business. BT had two main strands to its business – funds management and trading in the foreign exchange and money markets.

In 1996 the New Zealand banking system was in a process of transition in other ways. One of these was with the payments system. New Zealanders had traditionally been high users of cheques, but among the new activities embarked on during the mid 1980s were some experiments with EFTPOS.[22] Once a single interoperable system was established in the late 1980s, EFTPOS volumes began to grow, and by the end of 1993 all banks had come to be participants in the system. Over the next few years, EFTPOS volumes grew rapidly, with at least part of this growth being a replacement for cheques, which are relatively expensive to process. Then, after 1998, credit card usage also started to grow, at least in part in response to the banks' development and promotion of card loyalty programmes.[23]

Transformation had also occurred in the banks' computer processing. During the early 1980s, the four trading banks that owned Databank had decided to confront the changing economic environment and the opportunities offered by technological advances in computing through a banking redevelopment project. Following its sign-off in 1983, this came to be known as IBIS (Integrated Banking Information System). The project came to be subject to a number of problems, not least of which were its scale and complexity, but the factor that finally led to its abandonment in 1989 was that such a co-operative computing project no longer made sense in a market where there was a range of new competitors with significantly lower cost computer systems. Moreover, the new competitors were not stuck in the straitjacket of a joint computer processing environment, and could thus respond much more readily to changing market conditions. In the new operating environment, the four banks that owned Databank were no longer interested in co-operating on computing, but wanted to be in a position to compete against each other, for which they needed to be able to control their own computing future.[24]

The transition for each of the four banks to running their own computer systems took time, but by 1996 the process had been largely completed, and part of the Databank system had become the foundation for an all-bank clearing system. This was under the control of a new company, Interchange and Settlement Limited (ISL), which was

[22] Although the introduction of EFTPOS coincided with deregulation, it was not dependent on or a consequence of it.
[23] Credit cards had first been issued by New Zealand banks in 1979.
[24] This history is discussed in greater depth in Matthews & Tripe (2004).

owned collectively by all the settlement banks (defined in terms of transaction volumes and use of their own accounts at the Reserve Bank for interbank settlement). This company contracted the actual processing to EDS, who had bought the Databank business from the banks that had owned it.

A number of the banks had undergone transformation in other ways. By the beginning of 1996, the BNZ had completed its absorption of NAB (NZ), Countrywide had completed the absorption of United Bank, the National Bank had completed the absorption of the Rural Bank, and the ANZ had largely completed the absorption of PostBank. Since the ASB had separated itself from the rest of the Trust Bank group it had developed a national network outside its home base of Auckland and Northland (although its branches were only in the larger towns and cities, and it did not try to achieve the breadth of network enjoyed by the four former trading banks). Trust Bank had managed to largely transform itself into a single national bank, with a portion of the bank having been floated on the New Zealand stock exchange in 1994.

When Trust Bank was floated, 87% of the shareholding had been retained by the nine community trusts which had previously been the bank's sole owners. These community trusts had agreed that they would retain their shareholdings for at least two years, but as that period reached its end in early 1996, speculation began to mount that Trust Bank could be acquired by one of its competitors. Westpac was the successful bidder, with NBNZ being unsuccessful, and later in 1996 Westpac adopted the name WestpacTrust to reflect the merger of the two entities.[25] Following the completion of this transaction, more than 99% of the New Zealand banking sector was foreign-owned, and the number of banks with significant retail business was reduced to seven.

It is not obviously a consequence of the new disclosure regime, but after the beginning of 1996 a number of new banks obtained registration. Rabobank obtained registration for a branch of the parent bank in April 1996. Bank of Tokyo-Mitsubishi (Australia) Ltd obtained registration as a branch in September 1996, followed in

[25] This was an attempt to preserve the association with the Trust Bank name, which was seen as having a strong association with the New Zealand community. A decision to drop "Trust" from the name and revert to operating as Westpac was announced in late 2002.

November by a branch of Deutsche Bank. Banque Nationale de Paris was registered as a branch in March 1997, with Kookmin Bank (from Korea) gaining registration as a branch in July 1997. ABN Amro obtained registration for a branch in March 1998, which it used to take over the business of Barclays, which was under pressure internationally, and which relinquished its New Zealand registration later in March 1998. In August 1998, Indosuez, which was by now trading as Credit Agricole Indosuez, also relinquished its New Zealand registration, on the basis that it could continue to service its New Zealand client base from Australia.

From the retail banking perspective, the big event of 1998 was the acquisition of Countrywide by the NBNZ, which gave the NBNZ the bigger role in the retail market that it had hoped to achieve with the purchase of Trust Bank. Following its acquisition of the Rural Bank in 1992, the NBNZ had had a relatively large proportion of its portfolio in rural sector lending (22.8% as at 30 June 1998), and a relatively small proportion of its portfolio in housing (32.9% as at 30 June 1998). This balance was now restored somewhat, with housing increased to 47.2% and rural exposures decreased to 16.2% as at 31 December 1998. The Countrywide banking licence was relinquished in November 1998.

1998 also saw Citibank selling its retail loan portfolio to AMP Banking, who obtained registration for the purpose in October 1998. AMP's other lending business, which had mainly been developed through a business called Ergo, was switched across to the bank towards the end of 1999. In June 1999, BT relinquished its registration, following the acquisition of BT's business worldwide by Deutsche Bank.

There was another rearrangement of banking licences in July 1999, with the registration of Rabo Wrightson Finance Limited, which later changed its name to Rabobank New Zealand Limited. This followed the relinquishing of PIBA's licence at the end of June 1999, although it had in effect ceased doing business some time previously. Rabobank New Zealand Limited was to be the entity that undertook most of the Rabobank group's rural lending, which it joined with business it had acquired with the purchase of Wrightson Farmers Finance. Data for Rabobank New Zealand Limited are consolidated into the financial reports for the Rabobank branch: the additional business undertaken by the branch is essentially corporate banking related.

The CBA (no longer government-owned following its privatisation during the 1990s) had been a long-term investor in ASB, but as at 1 October 2000 it moved to buy out the minority shareholding held by the ASB Community Trust, and convert the bank to a wholly owned subsidiary. In June 2000 it had registered a branch to cover its other business in New Zealand (which had not been consolidated into ASB), and since that time the CBA group has had two banks registered. The ASB figures are consolidated into the figures for the branch, however, although it is generally noted that the CBA does not have a lot of business outside of ASB (Note that the CBA's branch figures also include the group's insurance interests in New Zealand).

In March 2001, Banque Nationale de Paris, which was by then known as BNP Paribas, relinquished its registration, on the basis that it could service its New Zealand client base just as well from Australia. BNZ Finance, the minority shareholders in which had been bought out in the mid 1990s, relinquished its registration in June 2001, with the business being absorbed into a division of the parent bank.

Two new banks have been registered more recently, with a primary focus on retail banking. Kiwibank Limited (Kiwibank, originally registered as New Zealand Post Financial Services Limited, and owned by the New Zealand government through New Zealand Post) was registered in November 2001. St George Bank New Zealand Limited was registered in February 2003, and operates as a joint venture with supermarket chain Foodstuffs. St George Bank is a major retail bank in Australia, the fifth largest bank in Australia overall, with a strong concentration of its business in the states of New South Wales and South Australia.

In late 2002, AMP Banking announced that it would be selling its New Zealand banking business (as well as its banking business in the UK). This decision was a reflection both of the problems being experienced by the parent company and the lack of profitability being achieved by its operations in New Zealand. Its residential and retail portfolio was sold to HSBC, its credit card business to American Express, most of its commercial loan portfolio to GE (who had earlier purchased the Australian and New Zealand business of AGC from Westpac), with the balance to Strategic Finance Ltd, and its rural loan portfolio to Rabobank.

There have also been changes in the monetary policy implementation and interbank settlement arrangements over the period 1996 to 2003, which have impacted on the performance of New Zealand financial institutions. Key events in this respect have been the introduction of a real-time gross settlement (RTGS) system in 1998, and a change in the monetary policy regime by the adoption of an Official Cash Rate (OCR) system in 1999. The introduction of the OCR has been accompanied by a reduction in volatility in financial markets (Brookes & Hampton, 2000).

As at 31 March 2003, there were 18 banks registered in New Zealand. Only two of these were New Zealand owned, with a combined market share of total bank assets of 1.21%. A further 66.33% was Australian owned, 22.37% British owned[26], and 6.53% German owned. Remaining portions of the banking system assets were owned by banks from the Netherlands, the USA, Korea and Japan.

There were five major banks which undertook a full range of activities with both personal and business customers – ANZ, ASB, BNZ, National Bank and Westpac. TSB also had a branch network, although this was limited to Taranaki, and relationships with business customers tended to be limited in scope. There were two new banks focussed on personal retail customers, which were looking to operate branch networks using other rganizations' facilities – Kiwibank and St George Bank. Other specialist retail banks included Rabobank (NZ) Limited, focussed on farming business, and Kookmin Bank, whose business was largely with the Korean community. AMP Banking could also be classed as retail, although it was in the process of exiting the New Zealand market. The other seven banks – ABN Amro, Bank of Tokyo/Mitsubishi, CBA, Citibank, Deutsche Bank, Hong Kong Bank, and Rabobank Nederland – were essentially all specialist wholesale corporate banks, although Hong Kong Bank had a moderate amount of retail business, which expanded somewhat as a result of acquiring the retail banking portion of the AMP Banking business.

Towards the middle of 2003, Lloyds TSB announced that it wished to review its ownership of the NBNZ. A number of the major Australian banks expressed an

[26] This is on the basis that HSBC can be classed as a British-owned bank, although the New Zealand branch is actually a branch of the bank's Hong Kong business.

interest in buying it, but in the end the only purchaser to carry through and obtain a clearance from the Commerce Commission was the ANZ Banking Group Ltd, with the acquisition announced on 24 October, and settlement occurring on 1 December. The actual combining of the operations has been subject to number of restrictions by the Reserve Bank of New Zealand, and the formal combination of the two legal entities (and lapsing of the NBNZ's registration) did not occur until late June 2004. At that stage it was envisaged that the new bank, ANZ-National, would retain two separate brands, at least for a significant period into the future.

2.4 The banking sector and the New Zealand economy

The changes and developments in the structure and operation of the banking sector were not occurring independently of changes in the environment within which the banks were operating, and were accompanied by changes in the volumes of banking business.

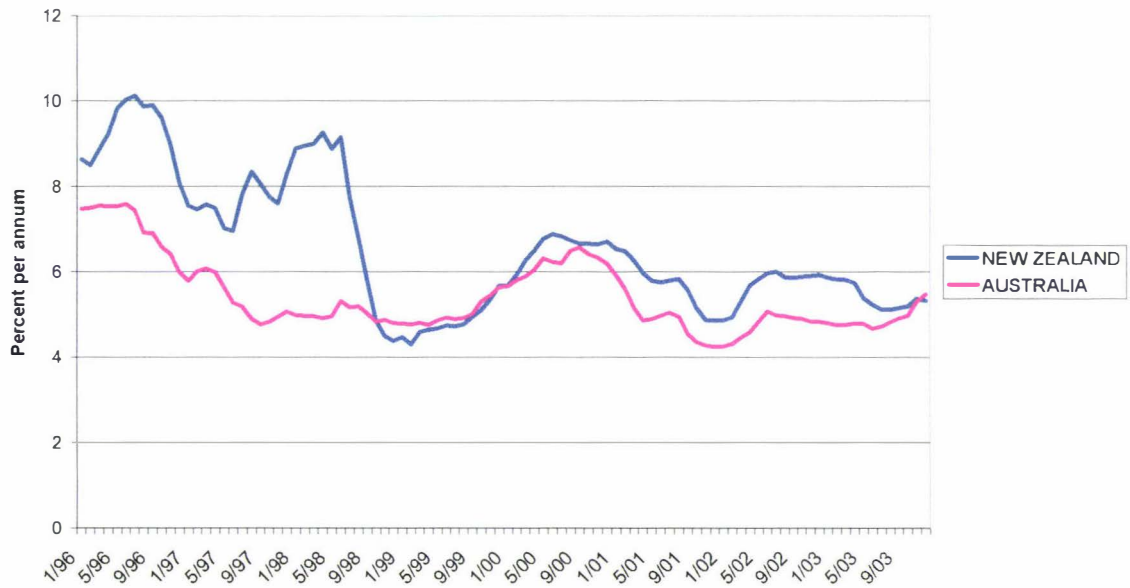
One of the issues that confronted the newly-elected Labour government in 1984 was a high base level of inflation in the New Zealand economy, even though this had to some extent been suppressed by the wage and price freeze imposed by the previous government. Part of the process of liberalisation was therefore directed at making monetary policy a more effective tool for the control of inflation. Market interest rates were therefore allowed to increase so that real interest rates became positive, and these interest rates became the key measure of monetary conditions. The combating of inflation was formalised in the Reserve Bank of New Zealand Act 1989, which provided for a target inflation level to be specified in a Policy Targets Agreement, with the initial inflation target set at 0 to 2%.

Because inflation had persisted since the early 1970s, there was a very substantial level of inflation expectations in the New Zealand psyche, and relatively high levels of interest rates were therefore necessary to achieve reductions in the rate of inflation. The key market interest rate, the 90-day bank bill rate, thus peaked at 35.5% on 8 March 1985 (exacerbated by the effects of the floating of the New Zealand dollar),

although there have been many reductions since that time. The 90-day bill rate was last above 15% on 18 October 1990, and last above 10% on 10 October 1996.[27]

For the period covered by this research, from 1996 to 2003, interest rates were still inclined to be relatively high, particularly when compared with other developed countries, and they were also inclined to be relatively volatile. The comparison with Australia, with data derived from the respective central bank web-sites (www.rbnz.govt.nz and www.rba.gov.au), is shown in Figure 1.

Figure 1 - 90 day bank bill rates between New Zealand and Australia

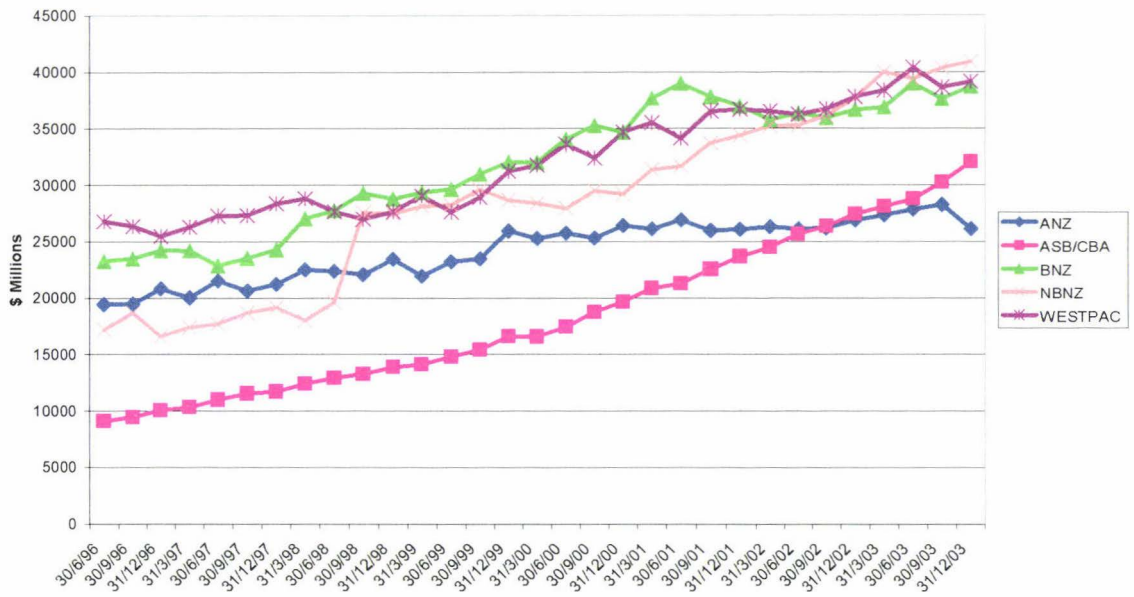


Another striking feature of New Zealand banking since the mid 1990s has been the very substantial growth in bank assets, with a particular growth in housing lending. The growth in housing lending was partly in reaction to the restrictions applying during the regulated period prior to 1985, when housing finance had been difficult to obtain through formal channels, as discussed in section 2.1. Banks relished their new-found freedom to lend in this area, and were encouraged to do so by the preferential risk-weighting for lending secured by residential mortgage under the (1988) Basel capital accord (although mortgage-secured lending as a proportion of total assets did not change significantly over the period 1996 to 2003).

[27] These data are obtained from the Reserve Bank of New Zealand's web-site, www.rbnz.govt.nz, Table B2.

There has nonetheless been a very substantial growth in banks' total assets over the period of this research, as is evident in Figure 2, which shows the end-of-quarter figures for the five major banks (with retail branch networks), derived form their consolidated statements of risk-weighted assets as part of the banks' quarterly disclosure statements. Other things being equal, one would expect this sort of bank asset growth to have had some impact on the way in which banks have gone about their business, and this is one of the issues explored as part of this research.

Figure 2 - Total asset trends - major banks



This asset growth has led to other changes in the way New Zealand banks operate, with a key change being evident in bank funding. In 1988, the assets of the New Zealand banking system were largely funded by New Zealand deposits, but since that time there have been changes in the patterns of bank funding. Particularly in the late 1990s, there has been very substantial growth in foreign funding of the banking system.

2.5 What does this mean for research?

Deregulation of New Zealand financial markets was undertaken with a number of objectives, and in anticipation of a number of outcomes being achieved. Many of these outcomes were reported by Harper (1986), and it is appropriate to look at what

he suggested as rationales for and potential consequences of deregulation, and at the extent to which some of the outcomes he suggested have been realised.

The first major argument offered by Harper was that the inputs used by financial firms are not generally highly specific to those financial firms. Major inputs are identified as capital (in the form of fixed assets), labour, materials, intangibles (such as information and brand-name capital) and financial inputs. Because of the flexibility in the way in which most of these inputs can be used (and, in cost terms, financial inputs are the most significant), it is relatively easy for financial firms to change their use of inputs and the outputs they generate from them in response to market conditions, such as would have arisen from the financial reform process. Harper highlighted the differences between financial firms and other types of firms with much more substantial investments in specialised plant in this respect (p 60).

From this argument, Harper therefore argued that there ought to be economies of scope in the production of financial services, with economies of scope defined as the ability to produce multiple outputs in a single firm at lower cost than producing the same outputs in individual specialist firms. An example of this would be in a single financial firm being able to process transactions to both current and savings accounts more cheaply than institutions which are only able to operate one type of account. Harper noted that economies of scope were perceived as being important as the previous functional regulation of New Zealand financial institutions had limited firms in the range of activities they could undertake. Information and know-how were identified as key inputs into financial institutions' production processes, giving rise to economies of scope.

Economies of scope are contrasted with economies of scale, which arise when the cost of producing an output increases less than proportionately with an increase in the quantity of output. Harper assumed that there ought to be economies of scale in the production of financial services, although the amount of research that had been undertaken internationally to that stage was relatively limited.[28] He promoted the desirability of research into economies of scale and scope for New Zealand financial

[28] Subsequent international research on economies of scale and scope in financial institutions is discussed in Chapter 3.

markets (p 67), but then noted that the small size of the New Zealand market constrained firms from enjoying economies of scale, which meant that they ought therefore to be pursuing economies of scope (p 67).

A key factor in why information is so important to economies of scope was identified in being the difficulty in transferring it from one firm to another. This was seen as leading to the formation of conglomerates, and it is interesting to note that one of the examples Harper used was the National Bank group (p 88). At the time he was writing, this consisted of four separate entities – the National Bank, Southpac (a merchant bank), General Finance (a finance company), and Equus (an investment company). Within five years of Harper's description of this situation, the only surviving standalone entity was the National Bank, into which significant portions of the other businesses had been absorbed.[29]

A final point Harper suggested was that conglomerates might not always result in efficiency. Limits might be imposed on diversification from diseconomies of scale and scope. These might arise from excessive demands on management, and from the increased complexity of the firms.

Since Harper wrote his report in 1986, there has been very little exploration of the issues he raised in respect of the efficiency of financial institutions, that might have been expected to have arisen as a consequence of deregulation. That alone would provide justification for the proposed research, but there are additional reasons as to why one ought to be interested in financial institution efficiency.

One of the key steps in the process of financial sector deregulation was the enactment of the Reserve Bank of New Zealand Act 1989. There are two separate places where the Reserve Bank of New Zealand Act refers to a "sound and efficient" banking system - Section 10, in the context of monetary policy, and Section 68, in terms of the supervisory oversight of banks. Dawe (1990) suggests that Section 10 of the Act means that monetary policy should not be managed in such away as to cause

[29] The major exception to this was the remaining portion of the General Finance business, which was sold to National Mutual, and which thus became part of National Mutual Bank. The history of the National Bank of New Zealand over this period is reported in Holmes (2003).

instability or inefficiency in financial markets (p 33), while Mayes (1998), in highlighting the expression "sound and efficient" (p 13), seems to be more interested in sound rather than efficient. The Reserve Bank has not defined what it means by efficient: one of the issues to be explored in this thesis is what efficiency might mean, which will provide a foundation for exploring the extent to which the New Zealand banking system might be regarded as efficient.

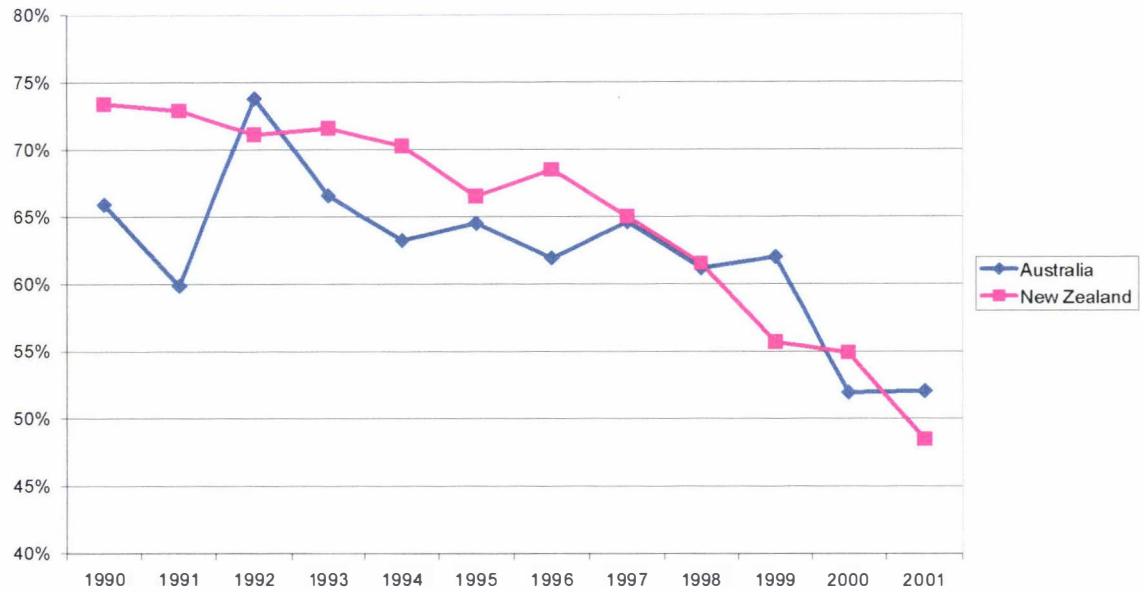
As part of what was in effect a study of the consequences of deregulation, Diewert & Lawrence (1999) looked at productivity in the New Zealand financial sector. This was part of a broader study looking at productivity in the New Zealand economy as a whole for the period 1972-1998, and which was generally concerned at the allegedly slow rate of productivity growth in the New Zealand economy. Diewert and Lawrence broke the data for the New Zealand economy down into 20 separate sectors. Almost all sectors of the economy showed improvement, but the outstanding disappointment was the financial services sector, which showed a 2.11% per annum decline in productivity over the period 1978-1998 (p 76).

Diewert and Lawrence noted that the reforms in the financial sector in the 1980s, together with the rapid change (improvement) in the range and quality of services offered make this result implausible (p 74). It was suggested that the problems might lie in the way both investment and output were measured, which made it difficult to identify changes in quality (although this problem is not peculiar to the New Zealand market). They also suggested that the estimated capital stock for the sector had increased at an implausibly fast rate.

Their finding was also inconsistent with the measure of bank efficiency that is most popular amongst bank managements, the cost to income ratio. The trend in bank cost to income ratios for Australia and New Zealand, based on the author's calculations from the OECD bank profitability reporting (OECD, 2002) is shown in Figure 3. Other things being equal, this graph would suggest that efficiency had improved in both countries, and one of the issues explored in this research is thus to look at the validity of the cost to income ratio as a measure of efficiency.

Another problem identified by Diewert and Lawrence in respect of the productivity of the financial sector was in the definition of financial sector output. This is an area which has been subject to significant theoretical review and empirical investigation, and it will be discussed further later in this research.

Figure 3: Cost to income ratios in New Zealand and Australia - all banks



There is a further point made by Diewert and Lawrence in their conclusion, which provides support and justification for this research. As part of the process of enhancing understanding of New Zealand's productivity performance, they suggest:

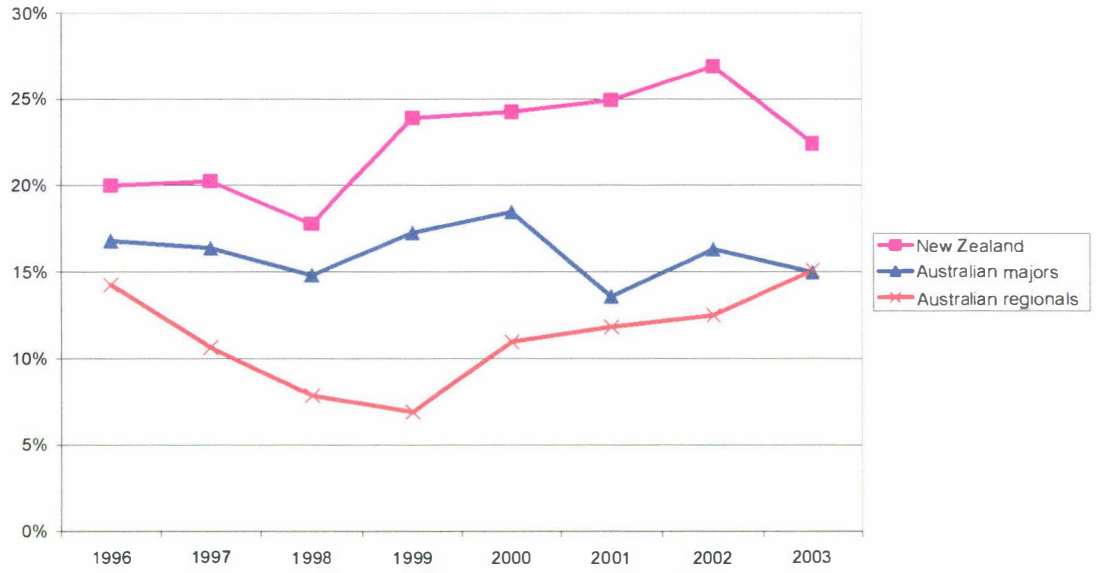
> "Benchmarking and DEA (data envelopment analysis) projects that would examine particular New Zealand industries or firms and compare their performance with international best practice. This would provide information on productivity levels as well as growth rates, while ensuring like is being compared with like" (p 160).

A range of issues has thus been identified for further investigation, in relation to the efficiency of the New Zealand financial system and the consequences of deregulation. A major thrust of this study is to look at the efficiency of New Zealand financial institutions (banks in particular), as a step to trying to understand something about the productivity of the New Zealand financial sector. There is a desire to find out how the

productivity of the New Zealand financial sector has developed through time, and also to see how the efficiency or productivity of New Zealand banks compares with those in Australia (and particularly those banks in Australia that own banks in New Zealand). There is also a need to have regard to competitive conditions, because of the impact they can have on efficiency, although initial research (Smith & Tripe, 2001) suggests that New Zealand financial markets have been relatively contestable.

The comparison with Australia is also important because a comparison of returns on equity, as seen in Figure 4,[30] shows much higher returns being earned in New Zealand than are earned by either the major or regional banks in Australia. This issue is explored further in section 5.4.

Figure 4: Relative Returns on Equity - Australia and New Zealand



This chapter has looked at the background of the New Zealand banking system relative to an evaluation of New Zealand banks' relative efficiency. The next chapter of this dissertation looks at prior research on measuring efficiency, and will provide some principles that can be applied in measuring the efficiency of New Zealand banks.

[30] These are based on the author's calculations from the respective banks' annual reports. The New Zealand figures cover ANZ, ASB, BNZ, National Bank and TSB; the Australian majors are ANZ, CBA, NAB and Westpac; the set of Australian regional banks comprises Adelaide Bank, Bank of Queensland, Bank West, Bendigo Bank, St George Bank and Suncorp-Metway. Further discussion of the Australian banking system is provided in section 4.1 below.

3. Previous research and theoretical issues

This chapter deals with a number of questions. It begins by looking at what might be meant by efficiency, and then goes on to look at efficiency in the specific context of financial institutions. This provides a basis for an examination of specific methods that have been used for studying efficiency, and efficiency in financial institutions in particular.

The latter part of the chapter then looks at some of the specific practical issues which otherwise get in the way of research, and at how these have been dealt with in previous research. This section has more of a focus on one of those techniques in particular, Data Envelopment Analysis, as this is the technique used in this research, but it also identifies issues that need to be addressed in other approaches.

Following this outline of previous research, the following chapter explains the actual methods to be used in this research, results from which are reported in Chapter 5.

3.1 What is efficiency?

The concept of efficiency may be regarded as one of the fundamental precepts of economics, and one which also has welfare connotations. Efficiency may be defined as the ratio of the weighted sum of outputs to the weighted sum of inputs (Boussofiane et al, 1991). In general terms, a firm may be said to be operating efficiently if it cannot produce more output without a corresponding relative increase in inputs, or if it cannot reduce its inputs without a corresponding relative decrease in output.[31] More generally, a decision-making unit (DMU) will be 100% efficient if there is no scope for improvement in the ratio in which it converts inputs to outputs.[32]

[31] This assumes that there is no change or difference in the quality of inputs or outputs.

[32] This is consistent with what Cooper et al (2000) refer to as Pareto-Koopmans efficiency: a unit "is fully efficient if and only if it is not possible to improve any input or output without worsening some other input or output" (p 45). For the background to the terminology on efficiency, refer to their discussion on pp 68-69. See also Charnes et al (1985).

Efficiency can be discussed in a variety of different forms, not all of them necessarily totally consistent with the previous definition. Traditional microeconomic theory has long talked of economies of scale, where increased volumes of output are supposed to be able to be produced with less than proportionate increases in quantities of inputs (increasing returns to scale). In due course, however, economies of scale will be exhausted, and increased output will require a more than proportionate increase in inputs, a situation described as diseconomies of scale (decreasing returns to scale).[33]

This description of economies of scale is consistent with what is referred to as a U-shaped average cost curve, one of the implications of which is that there is a particular level of output consistent with a minimum level of average cost. Under such a view, there is likely to be a flat portion in the middle of the U, characterised by constant returns to scale, where there is a fixed (and minimum cost) relationship between output and utilisation of inputs.

It is more common in practice to focus on the left side of the U-shaped average cost curve, where increases in outputs are associated with less than proportionate increases in inputs. A possible source of such positive scale economies in banking might arise from using a computer system to process customer accounts: more accounts can be processed without a corresponding increase in computing costs (Mester, 1987).

Another type of efficiency is economies of scope. The essence of these is that firms should be able to produce multiple outputs from the same group of inputs at lower cost, in terms of inputs, than if they specialised in producing only one type of output. Clark (1988) identified economies of scope as existing where the total costs from joint production of all products in the mix were less than the sum of the costs of producing each product independently (p 18). In the context of a financial institution, one might be looking at a situation where a firm produced both loans and deposit services, using the same staff and branch networks, rather than specialising in just one of these functions by itself.

[33] This discussion is directed at scale economies in a static context. Issues relating to changes in efficiency arising from changing production functions through time are discussed further below.

Mester (1987) notes that, at least in financial services, economies of scale and scope may arise at the same time. The use of a computer to realise economies of scale in account processing may be accompanied by use of the same computer system to process several different types of account simultaneously.

Clark (1988) identified a relationship between economies of scale and scope and the structure of firms in an industry. If the available technology allows for both economies of scale and scope, the industry will tend to be made up of large diversified firms, producing at lower unit costs, and using this advantage to gain market share.[34] If the technology does not allow for economies of scale or scope, small specialised firms will dominate the industry. If there is an absence of significant economies of scale or scope, there is likely to be a mixture of larger diversified firms and smaller specialised firms (p 17).

These discussions of economies of scale and scope in the previous paragraphs may be construed as assuming that firms are operating on some sort of production possibility frontier, and that it is only a matter of achieving an efficient level of production or mix of outputs. This will often not be the case, thus providing a basis for the concept of X-efficiency, as proposed by Leibenstein (1966). If a firm is X-inefficient, it is likely to be capable of producing more output for any given level of inputs, perhaps by a better utilisation of resources, reorganisation of the production process so as to make better use of available technology, better purchasing of inputs, enhancing staff motivation, or by any one of a range of other improvements.[35]

X-inefficiency is commonly broken down into 2 elements, allocative inefficiency and technical inefficiency, in terms of the approach outlined by Farrell (1957).[36] Technical efficiency might be conceived in simple terms as a measure of whether the firm is maximising production from the inputs it is using, while allocative efficiency looks at whether the best combination of inputs is being used, having regard to their relative cost. Frei et al (2000) distinguish X-efficiency, suggesting that:

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[34] This is the so-called Efficient Structure hypothesis, which may be contrasted with the Structure Conduct Performance hypothesis. See, for example, Berger (1995) for a review of these.
[35] Stigler (1976) suggested that differences in X-efficiency should be attributed to differences in technology.
[36] Although Farrell referred to allocative efficiency as price efficiency.

"... X-efficiency describes all technical and allocative inefficiencies of individual firms that are not scale/scope dependent. Thus X-efficiency is a measure of how well management is aligning technology, human resources and other assets to produce a given level of outputs." (p 260).

Attempts to measure X-efficiency generally occur relative to an efficiency frontier, with firms' technical efficiency being defined in terms of their relative distance from the frontier (which then becomes the benchmark for optimum performance). Allocative efficiency will then be identified according to whether firms are producing at that point on the efficient frontier that minimises input costs. This can be explained using Figure 5.

Figure 5: X-efficiency and its decomposition into technical and allocative efficiency.

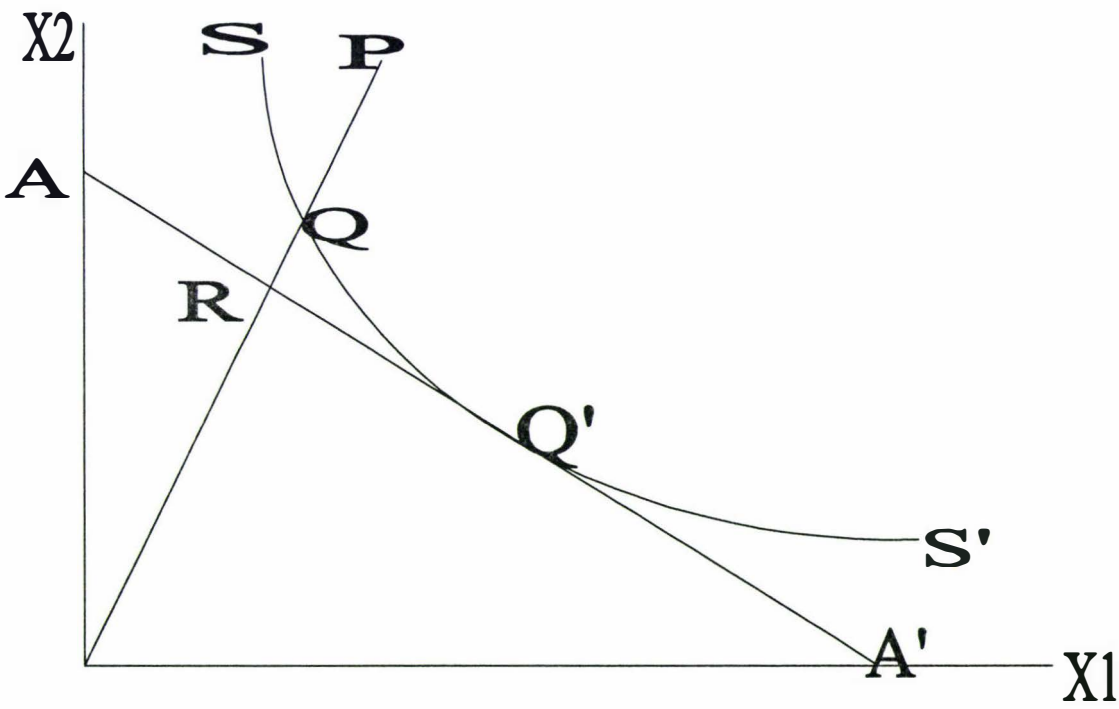

Figure 5 is commonly referred to as the Farrell diagram, after Farrell (1957, Diagram 1, p 254). X1 and X2 represent inputs, with the line SS' representing a fixed quantity of production with minimum utilisation of inputs (an iso-quant line, which makes up an efficient frontier). At point P, the producer is inefficient, as they could be using less of both inputs, and the producer may be said to be inefficient by the ratio of the

distance from the origin (which we will refer to as O) to point Q relative to the distance from the origin to point P. At point P the producer may be said to be producing with efficiency OQ/OP, which will be less than one, reflecting an over-utilisation of inputs. This is a measure of technical efficiency.

The line AA' reflects the relative prices of the two inputs, and where this line is tangential to the iso-quant line (SS') at Q', the cost of production will be minimised. Although point Q is technically efficient, it is apparent that the cost of production could be further reduced if the point of production could be moved to Q' (which will have the same cost of production as point R, even though R is not technically feasible). The move from Q to Q' represents a further source of inefficiency, referred to as allocative inefficiency, which arises from use of a less than-cost-minimising combination of inputs. The amount of allocative inefficiency is reflected in the distance QR, with the measure of allocative inefficiency being OR/OQ.

Total inefficiency thus comprises OR/OP, but with this able to be decomposed into technical and allocative inefficiency.

Siems & Barr (1998) distinguish technical and allocative efficiency as follows, with X-efficiency referred to as economic efficiency:

> "Allocative efficiency is about doing the right things, productive efficiency is about doing things right, and economic efficiency is about doing the right things right" (p 13).

Efficiency defined as above, relative to a frontier, is generally only a measure of relative, rather than absolute efficiency (Methods for specifying the efficient frontier are reviewed in section 3.3 below). Measurement of absolute efficiency would require knowledge of the optimum productive process (in an engineering sense), which would then become the benchmark against which other units' efficiency could be compared: there is no such agreed model for banking firms. When measurement is only of relative efficiencies, it is not in general valid to compare efficiency estimates derived from different samples.

It should also be noted that efficiency, as a measure of productivity, is not the same as profitability, although the concepts are related to each other. Grifell-Tatjé & Lovell (1999) noted that a change in a firm's profits may derive from a number of sources, including a change in input or output prices. The other sources of profit change are likely to be measured using the techniques of efficiency analysis, including technical change leading to an increase in output without any increase in resource utilisation, an improvement or decline in operating efficiency (X-efficiency), or a change in output proportionately greater or less than input utilisation, reflecting economies or diseconomies of scale. Further sources of profitability improvement include changes in product or resource mix, associated with economies of scope and allocative efficiency.

This review of efficiency so far has only been on a static basis, whereas it is arguable that one ought to look at changes in efficiency through time. There is an assumption that technological development should result in improved efficiency, and that one should therefore see a steady improvement in efficiency through time, but prior research suggests this is not always found, at least in financial services.[37]

If researchers are concerned with the welfare benefits of efficiency, the dynamic context is important, as this is what will provide for improvements in welfare through time. In broad terms, consistent with the concepts espoused by Schumpeter (1943), innovation and technological progress will thrive in a competitive market, and this is one reason why researchers should be concerned about competitive conditions.[38]

In terms of identifying the impact of technological progress and innovation, however, there are other issues to be appreciated. What technological progress might mean is that the efficient frontier, against which a firm's technical or X-efficiency is measured, might be expected to move through time. There is then a question as to

[37] See, for example, the findings of Mendes & Rebelo (1999) in respect of the Portuguese market. In some cases at least, this may be a consequence of deregulation and its effect on increasing interest costs (Humphrey, 1991; Lozano-Vivas, 1997; Lozano-Vivas, 1998), and thus, once the process of deregulation has run its course, efficiency may start to improve (Kumbhakar et al, 2001). It is also possible that, in financial services, technological change may be reflected in improvements in service and product quality, such as through telephone and internet banking, which may be much harder to measure.

[38] See, for example the discussion of Schumpeter's dynamics in Molyneux & Shamroukh (1999), pp 88-91.

how an individual firm's efficiency, in terms of outputs relative to inputs, might change through time as the efficient frontier is itself moving. These changes might also be impacted by changes in the scale of production (Balk, 2001). One technique for exploring this process further is via the Malmquist Index, which is discussed in greater depth as part of section 3.3.

3.2 Efficiency in Financial Institutions

It follows from the previous section that there are three types of efficiency that one might want to explore in looking at financial institutions. One might be interested in economies of scale, economies of scope and X-efficiency, while one might also want to see how measures of efficiency have changed through time. Efficiency in financial institutions is and should be a matter of public concern, as not only can more efficient financial institutions be expected to be more profitable, but one should also expect financial institution efficiency to lead to greater amounts of funds being intermediated, and better service at lower prices for consumers. Other things being equal, more efficient financial institutions should exhibit greater safety and soundness (Berger et al., 1993b, pp 221-222), while also showing better credit quality in the loan portfolio (Berger & DeYoung, 1997). These issues also provide a basis for looking at the efficiency implications of both bank mergers and acquisitions and government policy initiatives.

Farrell (1957) made the point that, to properly measure efficiency one needs to look at the range of inputs that a firm uses, and make allowance for all of these. It was of no use just to look at the productivity of labour, for example, without regard to the range of other inputs used (p 253). Some attempts had been made to get around this by use of index numbers, but his intention was to get around the problems of these.

This point applies just as much to efforts to measure efficiency in financial institutions. Common approaches to measurement of efficiency in banks are inclined to focus on ratios of non-interest costs to average total assets (cost to assets), or non-interest costs to gross income (the cost to income ratio). As has been discussed elsewhere (DeYoung, 1997b; Tripe, 1998), these ratios have a number of deficiencies, most particularly in that they don't take account of differences in the business that

banks undertake, which will in turn be reflected in different combinations of inputs and outputs. DeYoung (1998) suggests that blind pursuit of accounting-based benchmarks might reduce a bank's cost efficiency by cutting back on those expenditures necessary to run the bank properly (pp 5-6). There is also the issue that ratios may be contradictory: if a bank performs very well in terms of one ratio but poorly in terms of another, how does one determine an overall performance ranking (Golany & Storbeck, 1999)?[39]

To take account of these issues, one therefore needs to look at banks on a multiple input and multi-product basis. Banks use a mixture of inputs to produce a mixture of outputs, and their reported average cost figures will depend just as much on the mix of inputs and outputs as on the rate at which those inputs are used to produce outputs (Mester, 1987). In looking at bank costs one needs to consider more than just operating costs, which account for only part of overall bank costs. Berger & Humphrey (1992b) highlight the effect of tradeoffs between price and service, and note that a bank with a less extensive branch network may pay higher interest costs to attract deposits, although it will have lower operating costs (p 559). As a general rule, larger banks will have lower (non-interest) operating costs but higher interest costs, reflecting their dependence on borrowed funds. The extent of banks' branch networks is important for similar reasons (Humphrey, 1990): where a bank does not have branches, it can be argued as reducing its operating costs by transferring these to its customers.

Similar issues can arise on the output side. Noulas et al (1990) show that attempts to aggregate outputs into a single index are invalid, and that one is therefore required to take account of the multi-product nature of large banks in seeking to measure their efficiency. Resti (2000) notes that techniques aimed at summarising multiple products had been proven to be too good to be true, since they required separability conditions not usually supported by empirical data.

[39] See also the criticism of use of ratios for the analysis of the performance of bank branches in Schaffnit et al 1997), p 273.

More generally, Berger et al. (1993b) note that financial ratios may be misleading because they do not control for product mix or input prices.[40] Moreover, use of a simple ratio cannot distinguish between X-efficiencies and scale and scope efficiencies (p 233). Thanassoulis et al (1996) suggest that use of a multivariate approach gives a more balanced approach to performance measurement than ratio-based performance indicators. Siems & Barr (1998) found positive relationships between bank efficiency, profitability and CAMEL ratings.

The first piece of empirical analysis undertaken, described in section 4.4.1 and reported in section 5.1, looks to provide a comparison of multivariate approaches to efficiency measurement and the cost to income ratios for a group of New Zealand banks.

Initial studies of bank efficiency were inclined to be focused on looking for economies of scale, although some attention was also given to economies of scope (Mester, 1987; Clark, 1988). Despite what Humphrey (1985) refers to as the conventional wisdom, earlier studies were generally unable to find evidence for economies of scale beyond a relatively small size for a financial institution (assets greater than $100 million). Evidence for economies of scope was also weak (Berger et al, 1987).

A number of methodological difficulties were identified with this earlier research, which cast doubt on the reliability of some of the results obtained. Humphrey (1985) noted the problem that could arise from looking at unit banks and banks with branches together: scale economies should be expected to be observed quite differently between the different classes of banks. Clark (1988) noted the difficulties in defining bank costs and outputs, and problems with data and statistical methodology. Thus, as Berger Hunter & Timme (1993) noted, studies which looked at larger banks found the minimum average cost point to be associated with rather larger banks, with assets between $2 and $10 billion. In more recent work, however, using data from the 1990s

[40] Thus Chu & Lim (1998) argue that it is more appropriate to consider interest expense as an input in efficiency studies, rather than deposits, because not all deposits carry the same interest expense (p 158).

as opposed to the 1980s, Berger & Mester (1997) have suggested that the most efficient scale size might be rather larger.[41]

McAllister & McManus (1993) explained what they perceived to be some of the methodological reasons for the earlier results, with a particular focus on the use of the translog cost function.[42] Using a different approach, they suggested that banks could operate at minimum constant average cost at asset levels between $500 million and $10 billion. Also using a different approach, Siems & Clark (1997) found banks' scale efficiencies to be essentially invariant above a relatively small balance sheet size.

Another problem identified by Berger et al. (1993b) was the importance of using a method which only measured scale efficiency for firms that were on the efficient frontier: this was not necessarily common, particularly prior to the work of Berger et al (1987). If one was not focusing on firms on the frontier for assessing economies of scale, one was in danger of confusing scale efficiencies and X-inefficiency. Berger & Humphrey (1991) found that X-inefficiency was a much more significant component of overall inefficiency than was scale inefficiency. Scale inefficiencies accounted for only 5% of costs, whereas X-inefficiencies were around 20%.

Humphrey (1990) highlighted the importance of the definition of costs to be used when trying to measure economies of scale. Larger banks are generally less able to fully fund themselves through retail deposits, and will thus have higher interest costs but lower non-interest costs than smaller institutions. If a researcher tries to measure scale economies using only operating costs, minimum costs will be found at a larger asset size than if all costs are considered.

Berger et al. (1993b) also identified methodological problems with prior work looking at scope efficiencies. The first problem they identified was with the translog cost function, which caused problems for zero output levels. A second problem related to

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[41] This would be consistent with the suggestion of Noulas et al (1990) to the effect that optimum scale might change for year to year, and that this might have been a particular issue in the 1980s when deregulation was still working its way through the system in the United States.

[42] Issues with the translog cost function will be discussed in greater depth as part of section 3.3, below. Humphrey (1985, 1990) pointed out that the translog was a considerable improvement on approaches used in earlier research, as it allowed for a U-shaped cost curve, which the Cobb-Douglas approximation of a production function did not.

difficulties in finding specialised firms: if one is to test for economies of scope, one needs firms producing single outputs to allow comparison with firms producing them jointly. The third problem also applied to the search for scale economies; to test for scope economies one needed to be comparing firms that were on an efficient frontier.

The beginning of a trend to investigation of X-inefficiencies was noted by Evanoff & Israilevich (1991), who also noted that a major cause of X-inefficiency might be regulation. Berger et al. (1993b) also called for further research into X-inefficiency, reflecting the dearth of such research to that stage, as well as more comparisons of X-efficiencies across borders, reflecting the increased level of competition between countries and the (sometimes) relatively large X-inefficiencies within countries. Measurement of X-inefficiency requires banks' performance to be assessed relative to an efficient frontier, and by 1997, Berger & Humphrey were able to report on 130 financial institution studies, covering institutions in 21 countries. Since that time, the number of studies undertaken has grown very substantially.

The overwhelming emphasis in the studies reviewed by Berger & Humphrey (1997) was in looking at banks in the United States, although there were also studies of savings and loans and credit unions. There were also studies which focused on the relative efficiency of branches of particular financial institutions.[43] Most of the non-United States studies were for countries in Europe, although studies were also reported from Canada, India, Japan, Mexico, Saudi Arabia, Tunisia and Turkey. There were also six studies which looked at multiple countries simultaneously, five of which were focussed on banks.

Berger & Humphrey did not report on any Australasian studies, whereas a number have now been published. New Zealand publications include Liu & Tripe (2002) and Tripe (2003). Study of financial institution efficiency in Australia has been more extensive, with studies of banks by Walker (1998), Avkiran (1999a), Avkiran (2000), Sathye (2001), and Sathye (2002). There has been rather more study of non-bank financial institutions in Australia, including, in respect of building societies, Esho & Sharpe (1995 and 1996) and Worthington (1998b), and in respect of credit unions,

[43] Athanassopoulos (1998) notes that these can have a role in exploring the sources of inefficiency in banks as a whole.

Brown & O'Connor (1995), Esho (2001), Garden & Ralston (1999), and Worthington (1998a, 1999a, 1999b, 2000 and 2001).

The more recent international research generally finds lower levels of X-inefficiency than was reported in earlier studies. This could be a reflection of the globalisation of financial markets and the accompanying competitive pressures making it more difficult for a financial institution to survive if it was significantly inefficient relative to its competitors (Mester, 1994; Bauer et al, 1998).[44] In some countries, this may be a reflection of deregulation.[45] On the other hand, it may be a reflection of the finding by Berger et al. (1993a) that larger banks are generally less X-inefficient than smaller banks.[46] Increased bank size and the greater number of non-US studies, which do not include the same number of smaller banks, may thus explain the lower levels of X-inefficiency observed.[47]

Berger & Humphrey (1997) noted that there was an important role for cross-country comparisons of bank efficiency because of harmonisation in European markets for financial services, and because of the more general consequences of globalisation (p 187). The difficulty with cross-country comparisons is that the regulatory and economic environments are likely to differ between countries, as will expectations regarding product offerings and customer service. These mean that it may not be valid to assume a common frontier for measurement of efficiency.

Berger et al (2000) elaborate on the issue in greater depth, and further note the potential impact of differences in the intensity of competition within countries. Along with the other factors reported above, this means that a finding of greater X-efficiency for banks in one country cannot be construed as meaning that banks from that country would be equally efficient were they to operate in some other country (p 49).[48]

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[44] See Tortosa-Ausina (2002a, 2002c) for further exploration of this issue, although some of the issues raised are outside the scope of this research.
[45] See, for example, Chen (2001) for a discussion of Taiwan.
[46] Thus Miller & Noulas (1996) find that large US banks (defined as those with more than $1 billion of assets) are inclined to show a higher level of X-efficiency, but some signs of decreasing returns to scale.
[47] See Alam (2001) for a discussion of the relationship between the number of firms used to estimate efficiencies and the scores generated.
[48] See also the findings of Claessens et al (2001) on the different interest margins earned by foreign and domestically-owned banks in different countries.

Operation in a different country would in any case be likely to be under different conditions from those which might be experienced in a bank's home country.

Various attempts have been made to overcome some of these problems. Berg et al (1993) in their study of Norway, Sweden and Finland used both separate frontiers for each country and then a common frontier, against which they conducted further tests for the robustness of the results they obtained. A number of similar approaches have been attempted, with a basic assumption that such efficiency differences as arise reflect differences in the technology that is used in different countries (Chaffai et al, 2001). This is a particular issue for studies that have used a common frontier, such as Fecher & Pestieau (1993), Allen & Rai (1996), Altunbas & Molyneux (1996), Altunbas et al (2001), Cavallo & Rossi (2001), Cavallo & Rossi (2002) and Maudos et al (2002). Pastor et al (1997) estimated separate functions for each country, but then attributed the very substantial differences in efficiency observed to differences in the technology employed. Carbo et al (2002) used a single frontier for their study of European savings banks, but this allowed them to look at banks in some countries for which purely national samples would have been too small to allow meaningful measures of relative efficiency.[49]

Athanassopoulos et al (2000) compared bank branch networks across three separate countries – the UK, Greece and Cyprus. They first constructed separate frontiers for each country, and then compared the performance of the efficient branches in each country against each other. They found the UK branches to be most efficient, but also, despite the much higher degree of regulation in Cyprus, that branches in Cyprus were not less efficient than those of the Greek bank studied.

Chaffai et al (2001) and Lozano-Vivas et al (2002) have argued that many of these earlier bank-level studies have not properly taken account of country-specific conditions or norms. Dietsch & Lozano-Vivas (2000) looked at the French and Spanish banking sectors relative to a common frontier, which incorporated country-specific conditions. Previous approaches could mis-state the relative efficiency of firms from different countries, because they did not account for cross-country

[49] Issues relating to sample size are discussed further in Section 3.3, below.

differences in demographic, regulatory and economic conditions beyond the control of firm managers within their inputs and outputs. These previous approaches might generate artificially low efficiency scores for banks in countries where operating conditions were unfavourable, and high scores where conditions were favourable (Chaffai et al, 2001, pp 147-148).[50]

In their study, Chaffai et al (2001) used separate frontiers for each country, but then looked at the differences between the frontiers applying to the four countries studied. Environmental differences were found to be greatly more important than technological differences, while German banks were the most efficient, followed by French and then Italian banks, with Spanish banks least efficient.

Lozano-Vivas et al (2002) first analysed banks from 10 European countries using individual country frontiers. They then used a straightforward cross-country frontier, which generated much lower average efficiency scores for banks from each country than from the individual countries looked at separately. They then developed a cross-country model incorporating environmental factors (with a procedure specified for identifying and incorporating these). Some significant improvements in average country scores then became evident, which highlighted the disadvantages of operating conditions in particular countries. The environmental factors found to be most relevant were density of demand (value of deposits per square kilometre), income per branch, equity over total assets and salary per capita.

Casu & Molyneux (2003) used both separate country functions and a combined one for the five countries whose banks' efficiencies were compared – France, Germany, Italy, Spain and the UK. Regression was then used in an effort to find relevant country specific factors, which they referred to as technological. They described these as reflecting a legacy of different banking regulations and different managerial responses to the changing environment (p 1873).

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[50] This appears to also relate to the discussion by Mester (1997) – a point specifically noted by Lozano-Vivas et al (2002) - of the differences in average X-efficiency between the third district and the whole of the United States, where average X-inefficiencies in the more narrowly-defined third district were rather lower. She rejected use of a single cost function model for the whole country. See the further discussion in Section 3.4.5 below.

One aspect which has received relatively little attention in this area is in making some formal attempt to ascertain whether a common frontier might in fact apply in cross-country analyses. Edvardsen & Førsund (2003) have looked at this issue in the context of the electricity distribution business in different countries, but there is limited other material.[51] This research will explore the appropriateness of assuming a common frontier between Australian and New Zealand banks, according to a method outlined in section 4.4.4, with results reported in section 5.4.

3.3 Approaches to efficiency measurement

Because there is no agreed set of engineering relationships defining a standardised set of production processes in banking, there is no simple, readily agreed approach for specifying the production function and related efficient frontier. Attempts to determine the position of the efficiency frontier are thus dependent on use of accounting information and any other measures of input or output volume that may be available. Berger & Humphrey (1997) identify five different approaches to determining the efficiency frontier. The three main parametric approaches to specification of the efficiency frontier are the stochastic frontier approach (SFA, also known as the econometric frontier approach), the distribution-free approach (DFA) and the thick frontier approach (TFA), while the two non-parametric approaches are data envelopment analysis (DEA) and the free disposal hull (FDH) method.[52] [53]

A major challenge for both sets of approaches is in distinguishing random error, arising from accounting practice or some other source, from inefficiency. Each of the parametric approaches has different ways of dealing with random error, whereas the

[51] Elyasiani & Mehdian (1992) suggest that the hypothesis of a common frontier can be tested by comparing the probability density functions of the two group, although it would seem that we might not know whether a difference was caused by a different efficient frontier, or by a difference in the relative efficiency of the banks being studied.

[52] Lists of approaches to frontier analysis often omit the FDH approach, which may be regarded as a special case of DEA. Thrall (1999) has criticised FDH as being devoid of economic meaning, but note also the defence of FDH by Cherchye et al (2000).

[53] Some work has been attempted more recently using a neural network approach. See Santin et al (2004) for a review of this.

non-parametric approaches have generally failed to deal with it at all (although recent work is exploring ways of dealing with it within DEA).[54]

SFA requires specification of a functional form for the cost, profit or production relationship between inputs, outputs and environmental factors, but problems may then arise from the way the functional form has been specified, in that it presupposes the shape of the efficiency frontier, and for the commonly used translog approximation, this may impose minimum costs over a relatively narrow size range, thus generating misleading interpretations in relation to economies of scale in particular (Berger & Humphrey, 1997; McAllister & McManus, 1993). One solution to this has been use of the Fourier-flexible form, but one is still then faced with the problem of distinguishing random error from inefficiency.[55] A common approach to this has been to assume that the errors follow a half-normal distribution, although Berger & Humphrey (1997) describe this as relatively inflexible. Other distributions include the truncated normal and gamma distributions, although use of these may lead to other problems (Berger & Humphrey, 1997, p 178).[56]

The DFA takes a different approach, assuming that random error will average out to zero over time, and thus requires use of panel data covering a sufficiently long time period for this to be possible.[57] The differences between individual bank performance and the frontier will thus provide a measure of inefficiency. An advantage of DFA is that it imposes a less restrictive form on the frontier production function than does the SFA, but it cannot capture X-efficiency changes within a firm over time (Berger, 1993, p 265). Moreover, its X-efficiency estimates for a bank apply only in respect of

[54] Note, however, the point made by Grosskopf (1996) that both the parametric and non-parametric approaches may be impacted by outliers. She notes use of chance-constrained programming as a solution to this in DEA.

[55] Berger & Humphrey (1991) refer to the need for ad hoc assumptions to disentangle inefficiency differences from temporary or random fluctuations in costs or output. Rime & Stiroh (2003) note that the Fourier flexible form requires the estimation of additional parameters, and it can thus be difficult to use for small samples.

[56] Berger & DeYoung (1997) note some significant differences in the results obtained from using a Fourier-flexible form rather than a translog cost function, and the truncated normal rather than the half-normal error distribution. Wheelock & Wilson (2001) outline some of the problems identified with use of the Fourier flexible form (pp 661-663).

[57] On the other hand, the time period must still be short enough so that the level of X-efficiency for individual banks does not change (DeYoung, 1997a). This is a more general issue with analysis of panel data, as is discussed further below.

a period of time, rather than in respect of individual (typically annual) observations (Berger & DeYoung, 1997).

The TFA specifies a functional form, and assumes that differences within the highest and lowest performance quartiles of observations (stratified in size class) represent random error, while differences between the highest and lowest performance quartiles represent inefficiency. TFA does not provide estimates of inefficiency for particular banks, but is intended to provide an estimate of the general level of overall inefficiency (Berger & Humphrey, 1997, pp 178-179). Berger & Humphrey (1991) identified a key advantage of TFA as being the lack of a requirement that the inefficiencies be orthogonal to the outputs and other regressors specified in the cost function (p 122). By contrast, Mester (1996) notes that the division into quartiles is to some extent arbitrary,[58] while there is also a potential econometric problem because of the pre-scoring having been based on average cost, which is a dependent variable. Bauer et al (1998) suggest that using only 25% of the data for any given year to estimate the cost function may add significant noise to the model, relative to other approaches.

DEA is a linear programming technique where the frontier is assembled on a piecewise basis from the best practice observations (which will then be classified as 100% efficient).[59] It does not specify any functional form for the data, allowing this (reflected in the weights for the inputs and outputs) to be determined by the data.[60] A major problem is that measurement error and luck are assumed away, with no allowance for random error, so that all variations are treated as inefficiency (Berger & Humphrey, 1991, p 120).[61] This means that the position of the frontier may end up somewhat artificial, leading to higher estimates of inefficiency than might be derived using a parametric approach.

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[58] Lozano-Vivas (1997) experimented with thirds and quintiles, and found that the larger the subsets used to measure best and worst practice, the smaller was the average inefficiency.

[59] FDH is a special case of DEA where the frontier is constructed as a series of steps between the points of optimal performance (whereas DEA assumes that the links, also known as facets, are straight lines).

[60] Elyasiani & Mehdian (1992) also suggest that DEA avoids the multicollinearity problems that plague the parametric approaches.

[61] Thus, as Favero & Papi (1995, p 388) note, it is important to check the robustness of the results obtained using DEA, using techniques such as looking at different input and output variables, and to be wary of outliers, to which DEA is much more sensitive. On the other hand, Chu & Lim (1998) suggest that, if audited financial statements are used, such errors will not be a problem.

The basic (multiplier form of the) DEA problem,[62] in the constant returns to scale version, can be expressed as a requirement to maximise efficiency, for output weights u and input weights v, for i inputs x and j outputs y (with bold to indicate vectors). If the weighted sum of inputs is set as 1, in mathematical notation this gives a requirement to

$$max_{uv} (\boldsymbol{u}y_j) \qquad (1)$$

subject to $\quad \boldsymbol{v}x_i = 1$

$$\boldsymbol{u}y_j - \boldsymbol{v}x_i \leq 0$$

$$u, v > 0$$

Evanoff & Israilevich (1991) noted that use of DEA limited scope to undertake statistical inference. A major reason for this is that the distribution of efficiency scores is neither known nor specified (Ferrier & Hirschberg, 1997), while they will also be dependent on each other. Efficiency scores will also be limited to the range 0 to 1, with a tendency for scores to be closer to 1, which means that, if one wishes to regress efficiency scores against environmental factors, one should use a logit or preferably tobit regression (Coelli et al, 1998, pp 170-171). OLS regression is not appropriate (Grosskopf, 1996).[63]

Some progress is now being reported in overcoming these limitations. Contributions in this area, based on the bootstrapping of efficiency scores, and aimed at developing a distribution for each DMU's score, include Ferrier & Hirschberg (1997) and Simar & Wilson (1998, 2000). Casu & Molyneux (2003) summarise some of this debate and utilise the resultant method in a study of banks from five European countries. An alternative line of research looks at the distribution of scores of all DMUs (Tortosa-Ausina, 2002b).

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[62] For a more extensive discussion of DEA mathematics, refer to Avkiran (1999b), Coelli et al (1998), and Cooper et al (2000), including the further references they provide.

[63] Note that OLS regression is sometimes used, but the parameter estimates will not be able to be relied on. Note also that any regression will have no regard to information contained in slacks and surpluses, potentially further biasing parameter estimates (Fried et al, 1999, p 251). Bhattacharyya et al (1997) adopt a quite different solution: in their initial analysis they used DEA, but then used output from SFA on the same data as the dependent variable for the regressions in which they explored the sources of efficiency difference. It is not immediately obvious that this will overcome the limitation caused by the distribution of efficiency scores, which must in any case be truncated at 1.

Note, however, that bootstrapping approaches will not deal with the problem of random error or outliers in the data from which DMUs' scores have been estimated.[64] There is no obvious approach to the identification of outliers which are inefficient (in that one cannot necessarily distinguish between inefficiency and random error in the case of low efficiency scores), but for firms that show as fully efficient, random error effects may be located by use of the super-efficiency model (Anderson & Peterson, 1993).[65]

The super-efficiency model generates an efficiency score for each DMU based on a frontier that comprises all the other DMUs in the set, and DMUs that were classed as CCR-efficient may thus achieve a super-efficiency score greater than 1. If a super-efficiency score exceeds 2, it is suggested that the DMU in question can be identified as an outlier, and that it should therefore be omitted from the analysis (Hartman et al, 2001). Although the super-efficiency scores are no longer censored at 1, caution is still required in undertaking statistical analysis, as the efficiency scores will still be dependent on each other.

Note that testing for the significance of differences in average DEA scores for groups of observations may be undertaken using the non-parametric Mann-Whitney test (Cooper et al, 2000; Casu & Molyneux, 2003). This may be preceded by use of the Kruskal-Wallis test to look for differences in the efficiency distributions for the different groups (Athanassopoulos et al, 2000). Other tests used include the median test, Wilcoxon test, Savage scores test, and Van der Waerden test (Grabowski et al, 1993; Fukuyama, 1993).[66]

Drake & Weyman-Jones (1996) suggest that DEA provides more straightforward observation-specific measures of inefficiency (i.e. at the level of the individual firm).[67] The ability to identify a peer group whose operations may be emulated or

[64] This point was highlighted by William Greene in discussion of a paper he presented at APPC 2004 in Brisbane, Australia on 16 July 2004.
[65] The super-efficiency model exists in more than one form – see Tone (2002). Note that the software DEA-Solver described by Cooper et al (2000) uses the Slacks-Based Super-efficiency model described by Tone (2002).
[66] Grosskopf (1996) notes that this latter group are generated as standard output from SAS procedures. Interestingly, she makes no mention of the Mann-Whitney test.
[67] We thus see Rezvanian & Mehdian (2002) running DEA in addition to a parametric approach, so that they could specifically investigate the production performance of a sample of Singapore banks. We

targeted provides a clearer agenda for the analyst as to what might be done to improve efficiency at the individual firm level (Avkiran, 2002, p 160).[68] This is at least in part because DEA is a methodology directed towards frontiers, in contrast with the focus on central tendencies in the regression approaches that underpin the parametric methods (Seiford & Thrall, 1990). Thus, as Charnes & Cooper (1985) explain it, "DEA optimizes on each observation, whereas the usual statistical regression optimizes across all observations" (p 61).[69] Another aspect of this is that DEA provides scope for specific analysis of slacks and surpluses (Fried et al, 1999).

DEA also allows study of jointly-produced multiple outputs, whereas the parametric approaches are normally limited to focussing on a single dependent variable, such as cost, revenue or profit[70] (Avkiran, 2002, p 50). The different outputs used in DEA may reflect different firm objectives, which might not so obviously relate to economic optimisation, such as service quality[71] (Soteriou & Stavrinides, 1997) or market value, particularly if the analysis is to support a benchmarking exercise (Bergendahl, 1998). Chu & Lim (1998) look at growth in assets as a performance objective. Resti (2000) notes the potential value of looking at intangible outputs such as service quality, customer and employee satisfaction, although he notes that the difficulty in using these is that their measurement is inclined to be difficult and uncertain. In this regard also, DEA does not require the assumptions of cost minimisation or profit maximisation (Alam, 2001).

Another issue is use of information on the prices of inputs to bank production. Price information is generally regarded as being necessary for the parametric techniques, whereas DEA can still be used to provide assessment of relative efficiency without this information, although as Evanoff & Israilevich (1991) and Berger & Mester

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also see Siems & Barr (1998) identifying DEA as a useful tool for benchmarking exercises, while Fukuyama (1993) justifies use of DEA to focus on results at the individual bank level.

[68] In fact, as Avkiran (1999b) notes, relative efficiency measures in DEA are only relative to the peer group of efficient firms against which an inefficient firm is being compared, rather than relative to the whole set of efficient firms. DEA also allows identification of a global leader, specified as the efficient DMU that most often appears in the reference set of inefficient DMUs.

[69] Elyasiani & Mehdian (1990) thus note that efficiency measures and the rate of technological change will be measured relative to the average performance of the sample, rather than relative to sample best practice.

[70] Resti (2000) identifies this as a particular strength of DEA, although Berger et al (1993a) note the advantage of the profit function in identifying inefficiencies on both the input and output sides.

[71] Note that Athanassopoulos (2000) has developed a set of models, the first stage of which generates a service quality measure as an output, which then becomes an input into the second stage DEA model.

(1997) note, one can therefore only study technical efficiency with no investigation of allocative efficiency possible.[72] More particularly, as Cooper et al (2000) describe it, for DEA the measurement units of the different inputs and outputs do not need to be congruent (p 22), allowing stock and flow variables to be dealt with in the same model. DEA can address both quantitative and qualitative data and discretionary and non-discretionary variables (Avkiran, 1999b, p 213; Golany & Storbeck, 1999, p 15).[73]

Another issue in the choice of approach, although not discussed by Berger & Humphrey (1997), is sample size. The parametric techniques require significant numbers of observations for their regressions, which will be of limited value if the number of observations in the data set is not significantly greater than the number of parameters estimated.[74] By contrast, as Evanoff & Israilevich (1991) note, use of DEA allows one to work with less data, fewer assumptions and a smaller sample (p 22). 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).[75] 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). Where a sample is small, it is possible that a high proportion of firms will be classed as efficient, some of which would not otherwise show as efficient if a larger sample were used. As Nunamaker (1985) has identified, inclusion of additional (input

[72] In this case, the efficient frontier may be described as a production frontier (Pastor et al, 1997). Berger & Mester (1997) thus suggest that non-parametric techniques thus focus on technological rather than economic optimisation (p 905). Some researchers using DEA who have tested for allocative efficiency have found it to be significant (e.g. Rezvanian & Mehdian, 2002), while others have found it to be insignificant (e.g. Aly et al, 1990; Ferrier & Lovell, 1990). On the other hand, Elyasiani & Mehdian (1990) highlight the unreliability of input price data, even if it is available.

[73] DEA may not face some of the statistical and econometric constraints that might impact on parametric approaches. Gong & Sickles (1992) thus note that DEA may be preferred over SFA where inputs are correlated with technical efficiency.

[74] This proved to be a constraint for Walker (1998), who looked at 12 Australian banks for 13 years.

[75] 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. Avkiran (2002) suggests a further rule of thumb – that a sample is large enough if the number of fully efficient DMUs does not exceed one third of the sample.

or output) variables in a DEA model cannot cause reported efficiency scores to be reduced, and may results in DMUs appearing to be more efficient.[76]

This pattern of choice as to the approach to be followed is inclined to resemble the wider international experience reported by Berger & Humphrey (1997), who found 69 applications of non-parametric techniques (almost all DEA) and 60 of parametric techniques amongst the studies they reviewed. They were otherwise unable to specify which approach might be regarded as best, although it is noted that their own research has almost always used parametric methods. The previous studies of financial institution efficiency in New Zealand (Liu & Tripe, 2002; Tripe, 2003) used DEA, as have most Australian banking studies. The exception was Walker (1998), who used SFA on panel data, although his research raised questions as to the homogeneity of the cross-section of banks and the possibility of technological change over the period studied. (These issues are discussed further below).

One approach to comparing techniques for efficiency measurement was the development of a set of consistency conditions by Bauer et al (1998). They suggested that the efficiency scores generated by different approaches should have comparable means, standard deviations and other distributional properties; that the different approaches should rank the institutions in roughly the same order, with mostly the same institutions ranked as most and least efficient. All approaches should show reasonably stable efficiency scores for the same institutions through time, efficiency scores should be consistent with market conditions, and reasonably consistent with other measures of bank performance. When they tested these, they found them to generally apply, apart from the much lower scores reported under DEA, for which they had no certain explanation.

A similar analysis, but only comparing three approaches, was applied to five European countries (against separate frontiers) by Weill (2004). He found that the results of the parametric studies did not correlate with the DEA results although the DEA efficiency scores appeared to be more closely related to other measures of bank

[76] This is consistent with the broader issue of dimensionality, discussed by Hughes and Yaiswarng (2004).

performance. His conclusion was to affirm that of Bauer et al (1998), that it was wise to try different techniques to affirm the results of any efficiency analysis.

Some other studies have used DEA because of small cross-sectional samples, as with Chu & Lim (1998) in their study of the six major banks in Singapore, where the small sample appears to have led to unduly high efficiency scores. Canhoto & Dermine (2003) made specific mention of sample size in explaining their choice of DEA to study Portuguese banks, as did Isik & Hassan (2003) in their study of Turkish banks.

One of the ways in which sample size is expanded in non-parametric studies is through use of panel data, which can also allow study of how particular institutions' efficiency is changing through time (Tulkens & Vanden Eeckaut, 1995).[77] One approach to this is window analysis, which entails using data for firms in different time periods as if they were separate decision-making units. This allows a financial institution to be compared both with other institutions in the current period, and with itself and other institutions in other time periods (Charnes & Cooper, 1985; Boussofiane et al, 1991; Yue, 1992; Cooper et al, 2000, pp 272-276). Lovell (1993, p 47) notes the role of window analysis in relieving degree of freedom pressures,[78] and also that it can assist in detection of outliers: an average score from a window analysis covering a number of time periods will be less impacted by the random error that may otherwise be regarded as a problem for the non-parametric approaches. This is because window analysis allows multiple estimates of efficiency for each DMU for each period. This might be particularly applicable in the case of quarterly data – where a small number of sequential quarters are being compared, changes in technology are unlikely to cause major changes in efficiency.[79]

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[77] Panel data has also been used to expand sample size to enable parametric studies using SFA, although as noted above in the discussion of DFA, there is then the question of whether the technology is sufficiently invariant over the time period in question (which is also an issue when using DEA – see below).

[78] This is the dimensionality effect referred to by Hughes & Yaiswarng (2004).

[79] Window analysis generally assumes that, since all units within a window are measured against each other, there is no technical change occurring within that window (Asmild et al, 2004, p 70). On the other hand, panel data can be analysed without this assumption, and if a change in efficiency scores is observed, the question can then be asked as to whether this is attributable to technical change. See also Tulkens & Vanden Eeckaut (1995).

Users of window analysis in banking include Yue (1992) who looked at banks in the U.S. state of Missouri, and Asmild et al (2004) who looked at Canadian banks. Use of DEA for panel data has been reported by Drake (2001) in looking at the UK market, where the cross-section of banks was not large enough for single year studies. Canhoto & Dermine (2003) used both a panel and individual year cross-sections in their study of Portuguese banks. Bhattacharyya et al (1997) used a panel (which they describe as a grand frontier) for their study of Indian banks, noting the advantage such an approach brought in terms of relieving degrees of freedom pressures and increasing the variation in calculated efficiencies.

The more common linear-programming based technique for examining changes in efficiency through time, and which potentially caters for technical progress, is the Malmquist Index, the first application of which in banking was undertaken by Berg et al (1992). The Malmquist Index uses panel data to derive a measure of total factor productivity change, which can in turn be broken down into change in technical efficiency and technical change (which would cause the efficient frontier to shift) (Coelli et al, 1998, p 222).[80] The Malmquist Index thus caters satisfactorily for firms that are not on the efficient frontier.[81]

The Malmquist Index works by comparing the quantity of output produced in period t+1 with that which would have been produced in period t+1 using the period t technology. The index is thus able to have a score greater than 1 if there has been technical progress, if the firm has improved its technical efficiency, or if both of those effects have occurred. In mathematical terms the Malmquist Index is specified in terms of distance functions:[82] where x and y refer to inputs and outputs respectively, an input-oriented Malmquist productivity change index may be formulated as follows (where the D refers to an input-oriented distance function):

$$M(y^{t+1}, x^{t+1}, y^t, x^t) = [D^t(y^{t+1}, x^{t+1}) / D^t(y^t, x^t) \cdot D^{t+1}(y^{t+1}, x^{t+1}) / D^{t+1}(y^t, x^t)]^{1/2} \qquad (2)$$

[80] Technical change and technical efficiency are alternatively described by Alam (2001) as "innovation and imitation" (p 122). Drake (2001) refers to them as the frontier shift and catching up effects (p 560). The Malmquist Index is a geometric mean of these two effects. For a further discussion of the decomposition of the Malmquist index, refer to Lovell (2003).

[81] This provides an advantage over some other index number approaches, which require the assumption that firms are cost minimisers and revenue maximisers (Coelli et al, 1998, p 221).

[82] For a more extensive discussion, refer to Färe & Grosskopf (1997) and Coelli et al (1998).

The Malmquist Index has become increasingly popular, and significant work has now been undertaken in banking utilising it. Looking at banks in Norway, Berg et al (1992) found the greatest productivity improvement amongst the least efficient banks, with relatively little improvement in efficiency for the most efficient banks. This finding would appear to be consistent with the suggestion in Section 3.2 above that differences in bank efficiency might be reducing in response to competitive conditions.

Looking at the United States banking market, Wheelock & Wilson (1999) found that banks became less technically efficient over the period 1984-1993. They attributed this result to technical progress having occurred faster than bank-level efficiency improvement. Using a different approach, Bauer et al (1993) also found negative total factor productivity growth for U.S. banks over the period 1977 to 1988: possible reasons suggested for this included flow-on effects from high interest rates in the late 1970s, the phasing out of interest rate controls, the effects of non-bank competition and quality improvements.

Isik & Hassan (2003) looked at the efficiency of the Turkish banking system over the period 1981 to 1990, which covered the period of deregulation. They found that there was initially a reduction in efficiency in some cases, but that, after around 1986/87, efficiency began to improve again. Over the whole period, pure technical efficiency and (to a lesser extent) scale efficiency both improved, although there was technical regress.

Leightner & Lovell (1998) and Gilbert & Wilson (1998) looked at the Thai and Korean banking systems respectively, over periods when deregulation was occurring. Considerable productivity improvement was found in both cases, particularly in Korea where events were reviewed over a 15-year period. Leightner & Lovell noted that productivity gains were more important when there was a focus on bank profitability rather than on Bank of Thailand objectives of increasing financial intermediation. Gilbert & Wilson found the most important changes to be in terms of technology used, which they associated with changes in mix of inputs and outputs.

For the Australian market, Avkiran (2000) looked at the period 1987 to 1995, and found that technical change had more of an impact than pure technical efficiency in respect of the observed improvement in total factor productivity. Sathye (2002) looked at the period 1995 to 1999 and also found some improvement in total factor productivity, which could in this case be attributed to pure technical efficiency.

As with any other analyses, if the Malmquist Index is to provide meaningful results, individual year cross-sections must be large enough to be able to distinguish inefficient banks. This was a constraint for Drake (2001) in his study of UK banks, where he attempted to overcome the problem by using multiple year (window) base periods.

One also needs to look at a long enough time period for significant technical change to occur. This appears to have been a constraint for Noulas (1997) in his study of Greek banks, where he looked for changes over a period of only two years.

Market conditions can also be a factor. Fukuyama (1995) looked at Japanese banks over the period 1989 to 1991, and found evidence of technical progress in the first year, to 1990, but technical regress between 1990 and 1991. It was suggested that this was a consequence of the bursting of the economic bubble in 1990, with the start of an economic downturn.

Bhattacharyya et al (1997) decided against using the Malmquist Index for their analysis of Indian banks, preferring instead to run a DEA study on a grand frontier of Indian banks for the period 1986-1991. They noted the advantages of this approach in providing a single benchmark against which to evaluate performance and its change through time. Such an approach also gets around the problem of an unbalanced panel, caused by the entry and exit of banks from the market.

Asmild et al (2004) have tried using the Malmquist Index and window analysis together in a study of the five major Canadian banks, a group which would be too small by itself to be able to be studied using individual year cross-sections. The problem they found was that because the window analysis-derived cross-sections covered a period of time, it was not possible to uniquely define the base period

technology to which the Malmquist Index should be applied. They studied a 20-year period, within which they used five-year windows, which they regarded as small enough to minimise the problems of unfair comparisons over time, but still large enough to provide a reasonable sample size.

3.4 Practical issues in Financial Institution efficiency measurement

The mere identification of the different techniques with which efficiency analysis might be undertaken is not the end of the process of preparation for efficiency analysis. There is a range of other decisions required of researchers and relevant issues are reviewed in this section. There is inclined to be some emphasis on Data Envelopment Analysis (DEA) in this section reflecting the use of this technique in the research reported later in this thesis, but many of the required choices relate to a broader range of approaches to financial institution efficiency measurement.

This section begins by looking at how scale economies can be investigated within DEA, reflecting a choice in the type of model to be used. The section then looks at another DEA issue, model orientation, although there is a related issue that needs to be considered in the parametric approaches, in terms of whether the analyst uses a cost, profit or revenue function.[83] Another issue that applies to almost all attempts to analyse financial institution efficiency is the identification of the inputs and outputs of the production process. Further issues to be considered in this section include the specification of the group of DMUs whose efficiency is to be compared, and the problems of time effects and interest rates identified in Tripe (2003).

3.4.1 Returns to scale in DEA

An important issue that has to be decided with DEA is the type and orientation of the model to be used. DEA was originally developed on a constant returns to scale (CRS) basis by Charnes et al (1978), and then extended to variable returns to scale (VRS)

[83] For a discussion of cost and profit functions and the distinctions between them, see Berger & Mester (1997), pp 897-904. Note that some researchers (e.g. Berger & Mester, 1997; Lozano-Vivas, 1997) have used alternative profit functions, which take account of market conditions that are not perfectly competitive, by treating output volume as fixed.

form by Banker et al (1984), with the VRS version allowing for the separate identification of technical and scale inefficiency, as explained below.[84] The VRS approach also allows identification of whether a DMU is operating at increasing, constant, or decreasing returns to scale. By implication, a DMU's optimal scale of production can thus be identified.

Scale efficiencies are most commonly measured by running the same data through both the constant and variable returns to scale models: scale efficiency is found by dividing the CRS score by the efficiency score from the VRS model.[85] The difference between the constant and variable returns to scale models is that the VRS model envelopes the data points more tightly than the CRS model, and the efficiency scores from the VRS efficiency must therefore be greater than or equal to those from the constant returns to scale model. Scale efficiency measures will thus be in the range zero to one.[86]

Coelli et al (1998, p 150) note that the VRS model has been most commonly used since the beginning of the 1990s, and that would also be the case with DEA studies of financial institutions. Caution must be exercised in use of VRS models, however, particularly where cross sections are small, and where there is diversity in the size among the institutions being studied. As Dyson et al (2001) note, if a VRS model is used, small and large units will tend to be over-rated in the efficiency assessment. This means that scale inefficiencies identified for such institutions may be spurious, with the actual cause of inefficiency being X-inefficiency.[87] If a CCR model is being used and it is found that a DMU is inefficient, it may be difficult to ascertain whether

[84] The CRS and VRS models are commonly referred to as the CCR and BCC models respectively, after the authors of the original articles.

[85] This generates what Schaffnit et al (1997) refer to as a spread ratio, which they define as the ratio of two efficiency scores for the same DMU. Although this is commonly used to provide measures of scale efficiency, it may also be used to assess models with different numbers of variables, data points, etc: Schaffnit et al suggest that the Malmquist Index is also a type of spread ratio when it is being used to compare different technologies. These issues are discussed again in the analysis which is described in section 4.4.4, and reported on in section 5.4. Note that such a decomposition is often also applied to the Malmquist Index, to identify the impact of scale effects on productivity changes through time, although this may raise issues with respect to the effects of changing output mix (Balk, 2001). See Lovell (2003) for further discussion of the validity of the scale decomposition.

[86] Note that this contrasts with approaches to identifying economies of scale under the parametric approaches, which look at the aggregate data set, rather than focusing on the level of the individual firm (Athanassopoulos, 1998, p 187).

[87] For a further discussion of this in a practical banking context, see Tripe (2003). This issue is explored further in section 5.2 below.

the source of that inefficiency is scale or X-inefficiency.[88] Lovell (2003) has thus noted that scale diseconomies may be perceived as a departure of the best practice technology from the benchmark technology.

Avkiran (1999B) has suggested that researchers should run both CRS and VRS models. Then, "if the majority of DMUs are assessed as having the same efficiency under both methods, one can work with CRS without being concerned about scale efficiency confounding the measure of technical efficiency" (p 211).

A further feature of VRS models (in most DEA software) is that they report whether a DMU is operating at increasing, constant or decreasing returns to scale. Constant returns to scale will apply when the CRS and VRS efficiency frontiers are tangential with each other: in other words, when the (local) slope of the efficiency frontier is equal to the ratio of input(s) to output(s) (Cooper et al, 2000, pp 116-117). Increasing returns to scale must apply below that level, as the slope of the efficient frontier (which reflects the marginal rate of transformation of inputs to outputs) will be greater than the average rate of conversion (which is equivalent to the average cost). Likewise, decreasing returns to scale must apply must apply above the zone in which constant returns to scale apply. DMUs not on the efficient frontier must first be projected onto the efficient frontier before their returns to scale status can be assessed.[89]

The way in which returns to scale status is commonly determined is by running a non-increasing returns to scale (NIRS) model. A NIRS model can only show constant or decreasing returns to scale, and thus, if the efficiency score under NIRS is the same as under a VRS model, the DMU must be operating at decreasing returns to scale. If the scores are different, with the NIRS score lower than the VRS score, the DMU is operating at increasing returns to scale (Coelli et al, 1998, pp 151-2; Avkiran, 1999B, pp 211-212; Seiford & Zhu, 1999; Avkiran, 2002, p 58).[90]

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[88] This problem is compounded by the tendency for X-efficiency to increase with a financial institution's size (Berger Hancock & Humphrey, 1993), as discussed above in section 3.2.

[89] Golany & Yu (1997) highlight some of the complexities and potential inconsistencies in this process. This relates to the problem discussed in section 3.2 above of defining the returns to scale status of firms that were not on the frontier (Berger et al, 1987; Berger et al, 1993b).

[90] Some DEA software reports return to scale status analysis from VRS model output, relieving the researcher of the need to undertake this separate analysis.

Despite the methodological concerns, there is some consistency in suggestions that large banks may be scale inefficient, as was found by Drake (2001) in respect of the big four UK clearing banks, which were all found to be operating with decreasing returns to scale. Drake & Hall (2003) found a similar effect for the (large) Japanese city banks. Christopoulos et al (2002) found that large banks in Greece were generally less efficient than small and medium-sized banks. This is also consistent with the discussion by Berger & Mester (1997) where they note that previous studies (many of which used parametric methods) had found that cost scale economies were exhausted well below $10 billion of assets (p 927).

3.4.2 Model orientation

DEA models will commonly have either an input or an output orientation. An input orientation aims at reducing the input amounts as much as possible while keeping at least the present output levels, while an output orientation aims at maximising output levels without increasing use of inputs (Cooper et al, 2000, p 103). The focus on costs in banking means that input-oriented models are most commonly used, although in the CRS case, the same efficiency scores are generated by both approaches.[91]

This choice is also a reflection of what management is able to change. For a financial institution as a whole, it is easier to reduce inputs than it is to increase outputs, growth in which would be likely to be constrained by aggregate demand in the market as a whole (particularly if the market is not characterised by perfect competition), and which are not under management control.[92] Where inputs are not controllable by management, for example, for a comparison of a financial institution's branches, an output-oriented approach may be more appropriate (Avkiran, 2002, p 57).

If a DMU is identified as inefficient under an input-oriented approach, it will show as over-utilising inputs, but it may also show as under-producing one or more outputs.

[91] Even in VRS models, the same DMUs will be identified as efficient or inefficient, but the efficiency measures will differ (Coelli et al, 1998). This is because the efficiency score is being measured relative to different axes, according to the orientation of the model.

[92] See also the discussion of input and output orientations relative to the Malmquist Index in Pastor et al (1997).

This indicates an output slack. Similar circumstances can identify input slacks when an output-oriented approach is being used (Avkiran, 1999b).

There is some argument that restricting the choice to either an input or output orientation may neglect major sources of technical inefficiency in the other direction, which provided a justification for Berger et al. (1993a) to look at profit efficiency. There is therefore some interest in utilisation of the slacks based approach (Cooper et al, 2000), which is one of a set of what De Borger et al (1998) refer to as global efficiency measures, because they treat input and output dimensions simultaneously.

In his formal outline of the slacks-based model, Tone (2001) shows that a slacks-based measure is a product of input and output measures of CCR inefficiency, which means that any slacks-based measure must be less than or equal to a CCR efficiency measure with either input- or output-orientation. Tone further notes that the slacks-based model is thus providing measures of profit efficiency, rather than the ratio efficiency measures provided by the CCR model.

The slacks-based model allows for a further decomposition of inefficiency, in that a slacks-based efficiency score is a product of a CCR score and a mix-efficiency measure. This is argued as being appropriate and necessary because a CCR efficiency measure is based on a Farrell rather than a Koopmans approach to inefficiency, taking account only of radial slacks, and not of non-radial slacks (Ruggiero, 2000).

3.4.3 Specification of inputs and outputs

Another choice to be made in modelling bank efficiency is in specifying the inputs and outputs of the production process: differences in the input and output variables chosen are commonly found to impact on the efficiency scores generated, while Wheelock & Wilson (1995) state that unreliable estimates of efficiency can be generated by models that omit key features of bank production. Tortosa-Ausina (2002b) suggests that conclusions relative to the efficiency and potentially the competitive viability of firms in the industry could depend on the model chosen.

A distinction is made between the production and intermediation models, with the intermediation model existing in a number of different forms.[93] Under the production approach, banks are regarded as using labour and capital to produce deposits and loans, with both inputs and outputs typically measured as physical magnitudes, rather than in dollars. The intermediation approach sees deposits and other funds being transformed into loans (Sealey & Lindley, 1977), with its different versions including 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 (Berger & Humphrey, 1992a).

Even though the inputs may include actual money costs, because the production approach focuses on physical measures of inputs and outputs, the relevant data can be hard to obtain (except for the sorts of studies where the performance of a financial institution's branches are being compared). But the production approach also takes no account of the cost of deposits, which can be of particular importance because of the potential trade-off between interest and non-interest expense (Humphrey, 1991; Berger & Humphrey, 1992b).[94] On the other hand, the production approach may be more appropriate for examination of the comparative efficiency of bank branches, particularly where there are differences in the patterns of transactional activities. The majority of such studies of bank branches have used the production approach.[95]

If financial institutions were primarily or solely engaged in receiving funds at interest and using these to make loans, the asset approach might provide a fair enough description of their activities. It fails to take account of the other activities that banks undertake, however, for example in providing transaction services, which cause non-interest expense, and which in most cases contribute to non-interest revenue. If one looks at New Zealand banks, for example, it is found that approximately 35% of gross

[93] For some discussion of the origin of the different approaches, see Sherman & Gold (1985).
[94] Thus Berger et al (1987) note that the intermediation approach is to be preferred for competitive viability analysis because it is inclusive of both operating and interest costs (and a competitive firm would be seeking to minimise the sum of these for any given level of output).
[95] Athanassopoulos (1997) suggests that bank branch studies have either used DEA and the production approach, or parametric methods and one of the intermediation approaches (pp 302-303).

income is accounted for by non-interest income,[96] and omission of this would misrepresent the activities that banks undertake (Favero & Papi, 1995).[97]

Berger & Humphrey (1992a, p 247) note a further problem with the asset approach, giving the example of two banks that merge. Prior to the merger, one bank lends substantially to the other through the interbank market, but once the merger occurs, this output is no longer recorded, making it appear as if the merger has caused a reduction in aggregate outputs.

Berger & Humphrey (1992a, p 248) describe the user-cost approach as determining whether a financial product is an input or an output on the basis of its net contribution to bank revenue.[98] A major difficulty with this approach is with services that are not charged for, or where interest rates also include a component for other financial services. An example of this is with the non-payment of interest on current accounts to support the non-charging of transaction or account keeping fees. In the USA there has often been a requirement for compensating balances as a condition for loans.

Another complication with the user cost approach is that interest rates on both deposits and loans include some allowance for risk.[99] It may thus be difficult to distinguish whether higher interest rates on loans are a reflection of efficient pricing or of greater credit risk. Higher interest rates on deposits may be a reflection of deposits being taken for a longer term, with reduced exposure to liquidity risk, rather than being a reflection of inefficiency in raising funds.[100]

The value added approach considers all asset and liability categories to have some output characteristics, with those categories with greatest added value being recorded

[96] Based on data for the 6 banks that dominate retail business, for the period 1996-2002.
[97] Rogers (1998) goes further than this in highlighting the broad range of off-balance sheet activities that banks undertake, and the impact of these on measures of efficiency.
[98] This concept originated in the work of Hancock (1986, 1991).
[99] This was a basis for McAllister & McManus (1993) to include capital as an input in their model, although Mester (1996) proposes a number of further arguments for its inclusion. See also Hughes & Mester (1993) and the discussion in Berger & Mester (1997), pp 909-910. As an alternative approach to getting around this problem (and the potential effect of oligopoly power in the relative markets), Resti (1997) recommends using figures for deposit and loans, rather than for the interest flows relating to them.
[100] This issue may be mitigated by estimating profit efficiency rather than cost efficiency (Berger & DeYoung, 2001).

as outputs. Deposits are thus commonly recorded as outputs, although Hughes & Mester (1993) show that they ought more appropriately be classified as inputs.[101]

In practice, as Favero & Papi (1995) argue, all of these approaches have their strengths, but none of them is necessarily perfect. To properly account for a financial institution's performance, it is reasonable to also take account of off-balance sheet items (although these might be reflected in non-interest income), and capital. Thus, in their version of the asset approach, Favero & Papi include non-interest income as an output, to proxy for the services provided by banks. By contrast, Altunbas et al (2001) include total off-balance sheet items (measured in nominal terms).[102] The importance of off-balance sheet business as a source of non-interest income has been shown to have an impact on efficiency by Siems & Clark (1997) and Clark & Siems (2002). Siems & Clark (1997) suggested that the way in which off-balance sheet business was measured could have a significant impact on the efficiency scores generated.

In practice, the importance of some of the taxonomic distinctions may be overstated. One key factor that will determine what input and output variables are used will be what can be measured, and it most cases it is not possible to obtain data at a bank level for numbers of (deposit or loan) accounts or transactions processed.[103] One may also want to take note of input and output variables used in previous research, and the impacts of the variables chosen on the results obtained.[104]

A more important issue is one that is highlighted by Dyson et al (2001), particularly where using DEA, that the input/output set should cover the full range of resources used and outputs created, particularly if one really wants to assess a financial institution's efficiency at converting inputs to outputs, which should result in adding value. At the same time, the researcher will also want to be mindful of degrees of freedom constraints, and will want to avoid using these up by using input or output

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[101] Sealey & Lindley (1977), who are regarded as the originators of the intermediation approach, were firm in their view that deposits should be classed as inputs.
[102] Similar arguments might apply in respect of non-performing loans. See Berger & DeYoung (1997).
[103] One therefore often notes, with cross-country studies, that variables may be limited to what is reported on the Bankscope database. This is acknowledged, for example, by Maudos et al (2002).
[104] Nunamaker (1985) warns of the danger of choosing input and output variables so as to maximise individual firms' efficiency scores. This can be more of an issue under DEA than under other approaches, as one is using DEA to maximise efficiency scores under the DMU's best dimension.

variables which don't contribute to the identification of bank efficiency. Common sense and expert judgement can play a role in this. It is important to include key resources as inputs and to include in outputs those objectives which are regarded as key to the DMU's success (Avkiran, 1999b).

In practical terms, the way of investigating these issues is to look at the statistical relationships between the variables. Although some researchers report use of regression (Golany & Storbeck, 1999), it is generally regarded as satisfactory to look at correlation coefficients between the inputs, the outputs, and the inputs and outputs together. If inputs are highly correlated with each other, they are not going to effectively identify potential efficiencies (trade-offs) in input usage, and the discriminatory power of the model will be reduced accordingly.[105] Similar considerations apply with outputs.[106]

With respect to the correlations between inputs and outputs together, a typical criterion for inclusion is that correlations should exceed 0.7 (Avkiran, 2002) or even 0.8. The basis for requiring a high correlation coefficient is that this demonstrates that utilisation of a particular input is likely to have an effect on the quantity of output.

This may not be the end of the process of selecting variables, however. Hughes & Yaiswarng (2004) note that there may be several variables that reflect a DMU's activities, although no combination of these may fully capture all aspects of the group of DMUs' activities. In such a context it may be appropriate to try a range of variables and look for consistency in the ranking of results. Where the results are consistent, one can have greater confidence in the reliability of DEA models.

3.4.4 The impact of environmental factors

Checking correlations between variables is not a totally reliable basis for identification of appropriate input and output variables, however. Tripe (2003) identified a problem that arose with use of interest cost as an input variable, with

[105] This process should not be taken too far, however – see Nunamaker (1985).

[106] Avkiran (2002, p 40) notes that there will be no distortion in efficiency scores, but rather that the discriminatory power of the model will be reduced if highly correlated inputs (or outputs) are retained. This is the degrees of freedom problem, which tends to be much more of an issue in DEA where sample sizes are often quite small.

interest cost being highly correlated with the general level of interest rates. With net interest income as an output, the efficiency scores generated by the models used in longitudinal studies ended up being negatively correlated with the general level of interest rates. The suggested finding that New Zealand banks had improved their efficiency through time could not therefore be relied on.

If this particular combination of inputs and outputs had been tested using the correlation procedure outlined in section 3.4.3, they might well have been rejected from the model. This issue will be explored in greater depth in section 5.2 below.

This issue has been identified as particularly applying where there have been fluctuations in the general level of interest rates, but it may also apply in other circumstances as well. Care is required on the part of the researcher when there is found to be a relationship between efficiency scores and environmental variables.

Note that some of these issues ought to be able to be overcome in a DEA context by use of weight restrictions in a constrained multiplier model. Unconstrained DEA models allow each firm to be evaluated in the best possible light, but this can cause firms to appear to be efficient in ways that might be hard to justify in a logical approach. Constrained multiplier models incorporate prior knowledge and judgement into the evaluation of each firm. In their study, Siems & Barr (1998) obtained weights to apply to bank inputs and outputs from a survey of bank examiners.

3.4.5 Choosing the data set in which efficiency is to be measured

An important requirement for meaningful comparison of firms' efficiency is that the firms be sufficiently similar to make comparisons meaningful. This is particularly the case with DEA, where Dyson et al (2001) have developed what they describe as a series of homogeneity assumptions.

The first of these is that the units the performance of which is being compared should be undertaking similar activities and producing comparable products or services so that a common set of outputs can be defined. This might be extended to a requirement to use common technologies, but it is suggested that this should not be a binding

constraint (p 247). This also relates to the issues of whether or not a common frontier applies to all the firms whose performance is being compared (noting that this is a particular issue when comparing banks in different countries). There can be a role for the exercise of judgement by the researcher in this area: if there is a DMU in respect of which there is some doubt as to whether it ought to be included in a study, it may be appropriate for its effect on efficiency scores to be tested.[107] If it shows as overwhelmingly efficient, it may be an indication that its operations are different and that it ought to be omitted from the study.

The second homogeneity assumption (and a closely related implicit third assumption) is that a similar range of resources is available to all the units, and they operate in a similar environment. If the environments are different, these might need to be specifically accounted for in the analysis (p 247). Thus, for example, in their study of branches of a large bank, Golany & Storbeck (1999) started off with 200 branches, but reduced this to 182 because some of the branches were "..outliers, performing unique activities that other branches did not perform" (p 16).

In terms of banking studies, the consequences of use of heterogeneous samples have been demonstrated by Mester (1997). She found that studies that looked at only a single Federal Reserve district showed significantly higher average efficiencies than studies which looked at the United States as a whole. These issues would be likely to be of even greater significance in comparing the efficiency of banks across international borders.

These points raise a number of practical issues for research, particularly in DEA, where exceptional results are able to distort overall efficiency measures. This would particularly apply when comparing the performance of banks in a country which has its system dominated by a small number of large banks, such as New Zealand.[108] Banks could be classed as inefficient just because they perform distinct (more expensive) services (Tortosa-Ausina, 2004). Apart from the approach used by

[107] This testing may be undertaken using the super-efficiency model (discussed above), although alternative approaches include identification of DMUs which are in the reference sets for an overwhelming proportion of the inefficient DMUs.

[108] Isik & Hassan (2003) tested for whether domestic and foreign commercial banks in Turkey had identical technologies, and found that it was appropriate to construct a common frontier by pooling data.

Elyasiani & Mehdian (1992), however, there has been very little testing of the appropriateness of assumptions relative to whether common frontiers apply: this is one of the issues that the research reported in this dissertation attempts to address.

3.5 Summary

This chapter has sought to review a range of previous research, with a very specific focus on issues that would be expected to come to the surface in a study of the New Zealand market. It has thus not sought to provide an exhaustive literature review, but has summarised key points, and focused in more detail and depth on issues that will be discussed in subsequent chapters.

Key issues on which attention was addressed thus included the method to be used to specify the efficient frontier, studies of efficiency in cases where the number of firms whose efficiency is to be compared is small, and cross-country and inter-temporal studies. This background review should provide some justification for the use of Data Envelopment Analysis, while it should also have made clear that the relatively small number of banks in the New Zealand market poses a particular challenge for research into their relative efficiency. It was because of these constraints that it was necessary to review approaches to undertaking cross-country studies, and studies covering multiple time periods. But there was also an interest in studies covering multiple time periods because of questions over whether banks have become more efficient through time, reflecting the changes that have occurred in the New Zealand banking sector, some of which we reported on in Chapter 2.

With the relative theoretical background having been recorded in this chapter, the next chapter goes to look in more detail at the method to be used for the research, and at the data that are available to support it.

4. Data and Method

A number of the issues relating to the method used and data employed for this research have already been discussed in the previous chapter of this dissertation. This chapter seeks to justify the approaches followed in this research relative to that previous discussion. Thus, because of the relatively small number of banks with retail branch networks in the New Zealand and Australian markets, DEA is used, with an input-oriented model, to accord with the focus of many Australasian banks in trying to reduce costs, and to acknowledge that, in most cases, at the whole bank level, banks are much more readily able to influence costs than to affect revenues.

Partly in response to the wide divergence in asset size among the banks included in the research, but also reflecting some of the difficulties that can arise with variable returns-to-scale models, a constant returns-to-scale model has generally been used in the first instance, with the idea that a variable returns-to-scale model could be applied later to investigate the existence of scale effects. In a number of cases variable returns-to-scale models are run to check for scale effects, and these situations will be commented on in the description of results in the next chapter.

This research reports the results of a number of separate studies which build upon each other. These individual studies are discussed in greater depth later in this chapter. The chapter begins by defining the data set and then reviewing the data that is available on the New Zealand and Australian banking systems at an individual bank level. The chapter goes on to explore some general methodological issues before introducing the individual studies that make up this research.

4.1 The data set studied

In section 3.4.5, the problem of sample homogeneity was discussed, and it was noted that the firms involved in a study needed to be sufficiently similar to each other for their performance to be able to be meaningfully compared. This relates to the question of whether or not a common efficient frontier applies.

The primary focus of this research is on the six banks operating in New Zealand with extensive branch networks and a significant focus on retail banking: ANZ, ASB, BNZ, NBNZ, TSB Bank Limited (TSB) and Westpac NZ.[109] Although the New Zealand Government has established Kiwibank through New Zealand Post, it only commenced business in early 2002, and its relatively short period of operation and its failure to earn consistent profits during the period of the study would make it unfair to include it in the study, despite its extensive branch network.[110] Superbank, which commenced business only in February 2003, and which uses New World supermarkets and other Foodstuffs outlets as its public face, has been omitted from the study for similar reasons.

Some previous research (e.g. Liu & Tripe, 2002) has included a wider selection of New Zealand banks in its data set, to get around problems that would arise from use of a narrower data set, in terms of the models not having sufficient discriminatory power. In retrospect, it is not clear that that was necessarily a correct choice, in that the range of firms included in that previous research were too diverse in terms of the types of business that they were undertaking.[111] For this study it is regarded as preferable to use a narrower data set, which can be expanded by use of multiple periods of data in a single DEA model (as with window analysis or panel data approaches), so as to achieve an adequate sample size.

These concerns over homogeneity in the group of banks to be studied can be demonstrated by looking at a cross-sectional comparison of New Zealand banks' performance for financial years ending in 2003, and reported in Table 1 below.[112] There are significant and major differences in the percentages of net interest income, non-interest income and operating costs relative to average assets for the different banks, according to whether they have branch networks, while it is also evident that there are significant differences in bank size.

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[109] Although TSB is a great deal smaller than the other banks in the sample, the results generated do not suggest that it suffers in terms of the efficiency scores generated for it by the analysis: if anything, it shows as being more efficient. There is therefore no obvious basis for excluding it from this analysis.

[110] This approach can be justified in terms of previous research – see DeYoung & Hasan (1998).

[111] It was thus found that, in Liu & Tripe (2002), the set of efficient firms contained relatively little representation from the banks focused on in this research.

[112] No data are included for Superbank, as that bank had been operating for less than a full year, and was in any case very small as at its 30 September 2003 balance date (with total assets of only $76 million).

Table 1: Costs and Revenues for New Zealand banks in 2003

	Net Interest Income/ Average Assets (%)	Non-interest Income/ Average Assets (%)	Non-interest Expense/ Average Assets (%)	Average Assets ($000)
Full-service banks with branch networks				
ANZ Banking Group (NZ) Ltd	2.68	1.95	2.32	28,354,000
ASB Bank Ltd	2.40	0.89	1.57	25,880,150
Bank of New Zealand	2.40	1.41	1.71	36,754,000
National Bank of New Zealand	2.60	0.95	1.78	40,593,000
TSB Bank Limited	3.10	0.48	1.63	1,727,749
Westpac Banking Corporation	2.72	1.42	1.72	37,969,800
Specialised and new banks				
ABN Amro	1.08	4.90	5.48	782,461
AMP Banking	1.15	1.15	2.31	1,037,534
Bank of Tokyo-Mitsubishi	1.93	0.36	1.28	219,431
Citibank	0.51	0.85	0.62	2,424,997
Commonwealth Bank of Australia	0.25	0.72	0.22	919,268
Deutsche Bank	3.05	0.63	0.27	13,112,500
HSBC	1.42	0.34	1.16	5,820,792
Kiwibank	2.17	8.33	12.90	474,288
Kookmin Bank	0.91	2.12	1.21	218,774
Rabobank Nederland	1.89	0.25	1.15	3,411,568
Rabobank (NZ) Ltd	1.99	0.13	1.34	2,802,919

Source: KPMG (2004)

Data for the 6 banks that are the primary focus of this study, figures for which are shown in the upper part of Table 1, have been obtained from their quarterly disclosure statements, although some of the studies rely on annual financial results only (particularly where New Zealand and Australian performance is being compared, but also when an effort is made to eliminate some of the statistical noise that can otherwise arise in some of the quarterly figures). These banks together typically account for around 85% of the New Zealand banking market. In those cases where the performance of New Zealand banks was being compared with that of Australian banks, figures in New Zealand dollars were converted to Australian dollars at the average exchange rate for the period in question.[113]

[113] Exchange rate information has been obtained from the Reserve Bank of New Zealand's web-site at www.rbnz.govt.nz, Table B1.

The Australian banks included from time to time in this research are the four major banks – ANZ, CBA, NAB and Westpac – and the six so-called regional banks, each of which has a strong network presence in one or more states – Adelaide Bank (Adelaide), Bank of Queensland (BoQ), BankWest, Bendigo Bank (Bendigo), St George Bank (St George), and Suncorp-Metway Bank (Suncorp). Financial statements are publicly available for each of these banks as they are listed companies.[114] These 10 banks together have typically accounted for around 80% of the assets of the Australian banking system.

There was some concern as to whether it was valid to include Suncorp, because of that bank's very significant general insurance business, which can make it look rather different from its peers. As is demonstrated in Section 5.4 below, however, its inclusion can be justified.

Although quarterly data has been available for New Zealand banks since the beginning of 1996, data for the Australian banks has been annual, and the research has therefore been restricted to using annual results for the Australian banks. It is not believed that the diversity of balance dates has led to any significant distortion of results, and where, in the case of BankWest, accounting periods were for other than 12 months, figures have been adjusted.[115] Data for this group of Australian banks has been for the whole bank (i.e. including their New Zealand operations), reflecting what the banks publish.[116]

Although the study looks at the performance of banks over a period of 8 years from 1996 to 2003, data for the banks is used at current, rather than constant prices. Rates of inflation in both New Zealand and Australia have been low throughout the period of the study, and any differences in inflation rates between the two countries ought to be reflected in differences in the exchange rates between the two countries'

[114] BankWest ceased being listed during 2003 following its acquisition by its parent, HBOS, which previously held only a partial stake.
[115] One effect of this is that the results for BankWest described as being for 2002 and 2003 are actually for periods up to December 2001 and 2002 respectively.
[116] This is a potential distortion, forced by the data, although, as noted by Tripe & Matthews (2003), the New Zealand business comprises only a relatively small part of the banks' overall business. Since its acquisition of the NBNZ, the ANZ has had a much larger proportion of its business in New Zealand, but that is outside the period covered by this research.

currencies. Moreover, because all inputs and outputs are measured as monetary amounts, and because DEA looks at the ratios between the weighted inputs and outputs, there is no obvious distortion likely to arise from not converting these amounts to constant prices. It is further noted that any attempt to adjust would be likely to open up arguments as to what price index ought to apply.

Note that an advantage of not using data from earlier than 1996 is that the efficiency scores generated will not be impacted by the effects of deregulation. A number of other studies (some of which were discussed in section 3.3) have found that, because of the liberalisation of interest rates, the effects of deregulation can be hard to predict.

Now that the set of banks whose efficiency is to be reviewed in this research has been specified and justified, the next part of this chapter goes on to look at the data that are actually available for those banks, and at issues that may arise with the data.

4.2 Data: what is reported

The introduction of the disclosure regime in New Zealand at the beginning of 1996 has been a boon for researchers, as it has forced banks to publish financial statements and a range of other disclosures on a quarterly basis.[117] In particular, it has meant that disclosures have had to be made by all banks, not just those which were raising deposits from the public (the previous requirement), while the quarterly disclosures have meant that it is now possible to compile a snapshot of the whole banking sector for each quarter (subject to some limitations, discussed below).[118]

A key point in respect of the disclosure statements is the distinction between the on- and off-quarter disclosures. The on-quarter disclosures are made at the half year and at annual balance date, with more extensive disclosure required, including some adherence to accounting standards (with a more extensive set of notes to the accounts). Information requirements for off-quarter disclosures are less extensive.

[117] For information on what is to be disclosed, see Mortlock (1996).
[118] Although it is not included in the main part of the study, Countrywide Bank had a February balance date, which meant that its disclosures were as at the end of February, May, August and November. These were taken as being March, June, September and December respectively.

One of the problems for comparisons, however, is that banks' on- and off-quarters do not coincide. Of the 18 registered banks as at December 2003, one had a March balance date, three had balance dates in June, four at the end of September, and the other ten banks in December. Looking at banks by assets, approximately 50% of on-quarter disclosures were in March and September, which coincided with the other banks' off-quarter disclosures. With the ANZ's acquisition of the NBNZ, banks representing approximately 70% of assets are now providing fuller reporting in March and September.

Beyond that, as is discussed below, there are inconsistencies in disclosure, meaning that banks report the same information in different ways. For studies such as this, comparability of data is of particular importance, and the rest of this section is directed at data comparability. Note that another obstacle to comparisons is that some of the information disclosed may not be accurate, although such omissions are presumed to be more a reflection of error or inadequate information systems than of a deliberate desire to mislead.

The discussion that follows largely reflects the author's experience in reviewing the banks' disclosure statements as part of a process of public monitoring of bank safety and soundness. This monitoring process is reflected in the publication of a quarterly newsletter reviewing bank performance (Tripe, various).

4.2.1 The Income Statement

Comparison of income statements is important relative to studies of both bank efficiency and soundness because many of their individual components can give an insight into banks' operations. Relatively higher interest costs might indicate difficulty in raising funds because of a threat of insolvency or a trade-off with non-interest expense, while lower interest revenues might suggest a poorly performing loan portfolio or the failure of bank staff to negotiate appropriate returns from borrowers. Higher and more volatile interest revenues might be an indication of riskier lending. A higher level of non-interest expense might indicate that a bank was not operating efficiently, while insufficient profitability might imperil maintenance of its capital. In studying bank efficiency, costs and revenues are important because of

the potential for there to be trade-offs between different categories of cost, and between different categories of revenue.

The way New Zealand bank financial statements are presented poses a number of impediments to comparisons of profitability (although comparison of income statements is easier than comparison of balance sheets). This commentary looks first at interest income and expense, and then at non-interest income and expense. Problems are also noted with accruals.

One issue is the split between net interest income and non-interest income. It might be imagined that this distinction was straightforward, but that is not always the case. One area of concern is with revenues from financial instruments in the treasury-trading environment. Prior to a change in accounting policy reported in its March 2000 GDS,[119] Westpac had been reporting significantly higher interest revenues relative to interest-bearing assets, but it no longer has such a conspicuous advantage.[120]

Interest revenue and expense can also be impacted by swaps. Under normal circumstances, the types of hedging being undertaken will be broadly similar between banks, reflecting fundamental similarities in their underlying borrowing and lending business. If one bank's interest costs or revenues are significantly different from its peers, it can be difficult to know whether this is an on- or off-balance sheet issue (and whether this is an indication of a problem with the bank).

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[119] The statement of accounting policy (p 19) said that "the NZ Banking Group changed its disclosure of trading income to include, within the trading income line, the interest flows recognised as a result of its trading activities. These flows were previously disclosed as interest income and interest expense." There was no significant change in the bank's gross income (relative to average total assets) as a result of the accounting policy change.

[120] A further change in accounting policy in the June quarter 2001 has seen a guarantee fee now treated as a deduction from interest income, rather than being treated as an item of non-interest expense. Its interest revenues are now not significantly different from those of its competitors. Yet another accounting change has been implemented as at March 2004, although data used for this research are prior to the impact of that adjustment on the historical data. Comparative DEA models were run, using the two sets of Westpac data alternately, and differences in efficiency scores were minimal, apart from the September quarter 2003, where the model that used amended data showed significantly higher efficiency.

It might be argued that any serious problem in this respect will be reflected in the interest rate risk numbers reported in the bank's market risk disclosures.[121] This was observable to some extent in one case where a bank's market risk numbers were relatively higher than those reported by other banks, but it has not necessarily been the case otherwise. Opportunities for observation are in any case limited, as there has not yet been sufficient experience of bank problems with interest rate risk management.

A further issue with interest revenue is tax-effective lending. Where the lender is able to obtain a tax advantage (perhaps through funding borrowers by buying their redeemable preference shares, which pay dividends rather than interest), the lender can charge a lower effective interest rate.[122] The four major multi-market New Zealand banks with significant retail business (i.e. not including ASB) appear to have done this to some extent over the period 1998-2002 (as can be observed from their effective tax rates), with this reflected in lower levels of interest revenue. The problem for comparative analysis, however, is that it is not known how much of the reduced interest revenue was due to tax-effective financing, and how much to other factors. A solution might be for banks to identify the effect of tax adjustments on their interest revenues, as is done by one of the banks' parents (Westpac) in its consolidated (Australian) financial statements.[123]

Problems also arise in banks' reporting of non-interest income. One expects some differences in the amount of non-interest income banks report because of differences in their patterns of business, but it would be reasonable to expect that they might use a standard set of categories to report such income, allowing one to identify abnormal performance. No consistency is found in the categories used to report such income.

[121] Peter Ledingham of the Reserve Bank put this view forward in defending the disclosure regime in January 1997 (Staff, 1997). The method for calculation of the market risk disclosures is outlined by Harrison (1996).

[122] One bank actually reports the amount of its investment in redeemable preference shares, but it aggregates these into its loan portfolio for other reporting purposes. Such reporting is not mandatory.

[123] A further issue has arisen more recently with banks reducing their income tax still further through the use of conduits (involving loans from the parent companies re-advanced to other off-shore parties). See Llewellyn (2004), Hill-Cone (2004). This is not relevant to the current discussion, however, in that this research is only looking at taxes as per the income statements at the level of New Zealand registered banks. The relevant loophole is now being closed by the New Zealand government.

however, and as Table 2 shows, banks do not even use the same number of categories.[124]

Table 2: Reporting of non-interest income and expense under New Zealand's disclosure regime[125]

Bank	*Number of categories in which non-interest income reported*	*Number of categories in which non-interest expense reported*
ANZ Banking Group	10	13
ASB Bank Ltd	9	10
Bank of New Zealand	12	17
National Bank of New Zealand	5	9
TSB Bank Ltd	3	7
Westpac	8	13

Another issue with non-interest income (or expense) is the failure to identify unusual, extraordinary or abnormal items. This means that such income (or expense) is often lumped in with overall non-interest income (or expense), and may not be separately identifiable until the next on-quarter disclosure statement. This may be causing banks' non-interest income (or expense) to appear more volatile.[126] Accounting standard-setters may argue that treating items as extraordinary when they are not can be a way of manipulating financial statements, but failure to identify unusual events can be just as misleading. This type of issue can be important when using DEA, which does not cater for random error in data, but this research has generally sought to overcome problems of this type by separately classifying items which might be regarded as extraordinary.

Problems in the way non-interest expense is reported are not dissimilar to those experienced with reporting non-interest income. As with non-interest income, more extensive breakdowns are provided in notes to the accounts in the on-quarter

[124] In the case of TSB Bank, however, this may be a reflection of the more limited scope of its business, a point which also applies to Table 3.

[125] For Table 2, figures are as at 30 June 2003 or 30 September 2003, according to whichever was the relevant on-quarter date for disclosure. By 31 December 2003, the NBNZ's accounting practices were changing to conform to its acquisition by the ANZ. Figures have been derived from an examination of the banks' disclosure statements in each case.

[126] A notable case of this was a profit on sale of equities reported by Westpac in the March quarter of 1997. For further discussion, see the author's bank performance newsletter for that quarter. Later Westpac disclosure statements in that financial year commented on the unusual items of non-interest income. It has also been difficult to identify the extraordinary component of NBNZ's non-interest expense in the December 2003 quarter, with these figures apparently distorted by some one-off adjustments following the bank's acquisition by the ANZ.

disclosures, and some banks provide different breakdowns in the income statement and in the notes. The number of categories used is reported in Table 2.

Arguments also arise over the amortisation of goodwill through banks' income statements. Banks with significant goodwill on their balance sheets complain that their figures should be adjusted to reflect this, when levels of non-interest expense are being compared.[127] Goodwill generally arises from the purchase of another bank, however, and it is not obvious why such a purchase should be treated differently from the purchase of a new computer system (which is generally depreciated or amortised over a period of time). Goodwill usually arises because purchase price was more than book value, reflecting a strategic decision by the management of the bank that made the purchase. Should the costs of that strategic decision not be reflected in the bank's non-interest expense?

For the purposes of this research, operating costs are taken as inclusive of depreciation and amortisation of goodwill. With all banks having relatively low levels of fixed assts, depreciation (which can be considered as a proxy for occupancy expense) should not vary greatly from bank to bank, although it may be inflated a little for banks with significant leasing business. Goodwill amortisation would be expected to have most impact on Westpac, but as will be seen, Westpac shows as most efficient even without adjusting for this.

A further point of concern is with accruals. If banks defer identification and reporting of expense items until the end of the financial year, how much confidence can observers have in the accuracy of financial statements in earlier quarters, particularly where bank auditors are signing off these disclosures?[128] This seems to be a problem for several banks, with smaller banks also from time to time showing unusual figures

[127] The New Zealand bank with significant goodwill has been Westpac, for which goodwill amortisation in the year to 30 September 2003 represented 0.12% of average total assets (or 7% of non-interest expense). ANZ has now (subsequent to the period covered by this research) acquired very substantial amounts of goodwill following its acquisition of NBNZ.

[128] Tripe (various) has criticised the Bank of New Zealand in particular for this practice, where there has been a tendency for operating expenses to increase in the September quarter each year (the final quarter of the bank's financial year).

for interest income and expense, which may relate to problems of this type.[129] This can provide some justification for use of annual figures in some of the following analysis.

By contrast with more commonly discussed cases of financial statement manipulation, however, operating costs have generally been increased (rather than, for example, being reclassified as capital expenditure). This has the effect of reducing reported profits, and raises questions about the possibility of profit shifting to reduce tax liabilities (Demirgüç-Kunt & Huizinga, 2001). This means that the data measurement errors that are commonly regarded as a problem with DEA are likely to cause efficiency to be understated in the relevant periods, rather than causing the position of the efficient frontier as a whole to be shifted by super-efficient observations.

4.2.2 The Balance Sheet

Comparisons of balance sheets and related information also provide perspectives on banks' current and potential performance and risk exposures. Issues focused on in this sub-section include the classification of lending and funding by sector, the split between wholesale and retail funding, and the information provided on liquid assets. Concerns might also be raised in respect of banks' identification of impaired assets, with the opportunity having been provided since mid-2001 to compare banks' practices in their approaches to classifying exposures to (what was assumed to be) the Central North Island Forestry Partnership.[130] If there were significant differences, it would make it very difficult to compare banks' credit risk exposures.[131] This is

[129] Another example was where one bank (TSB) used to adjust its general provision for bad and doubtful debts only once a year, but it has now changed its practice so that the provision is reviewed every quarter.

[130] This was discussed at some length in the author's bank performance newsletters from the March quarter 2001 through until the September quarter 2003 (Tripe, various). Practices were seen to vary considerably between banks, with one bank apparently deciding that at one stage its exposure did not need to continue to be classified as past due. By September 2003, all but one bank appeared to be classifying their exposures as non-accrual (or something similar). Subsequent draft amendments to the disclosure requirements were rather more stringent in respect of impaired asset reporting than have been the previous (current) rules. By the time of the December 2003 disclosure statements, the relevant exposures had been repaid without obvious significant losses.

[131] Accounting problems are not confined to New Zealand – see White (1997), pp 76-78. In New Zealand, a major problem with the basis of accounting disclosure is that the book value of equity appears to be much less than market value, which artificially inflates reported return on equity (thus impacting on the effect reported in Figure 4, Section 2.5).

unlikely to be properly tested until such time as a significant economic downturn is experienced, although it has no impact on the research reported in this dissertation.

The classification of lending and funding by sector should provide insights into banks' liquidity and credit risk exposures, but it is difficult to make comparisons between individual banks. This is because, as shown in Table 3, banks don't use the same number of categories, making it impossible to compare the relative significance of funding and lending in the different categories.

Another issue in assessing banks' liquidity risk exposures is their relative dependence on wholesale and retail funding. One might have expected this to be ascertained by looking at their dependence on funding from the finance sector (and from overseas), but the lack of consistent information on sources of funding limits the usefulness of these data. This difficulty is exacerbated by the sectoral breakdown only being reported in on-quarters.

Table 3: Number of sectors used for reporting funding and lending by sector under New Zealand's disclosure regime[132]

Bank	Number of sectors in which funding reported	Number of sectors in which lending reported
ANZ Banking Group	13	15
ASB Bank Ltd	7	8
Bank of New Zealand	10	11
National Bank of New Zealand	12	12
TSB Bank Ltd	4	9
Westpac	4	6

The way liabilities are recorded on bank balance sheets is often no more helpful. All banks separately identify deposits from banks (although not all funding from other banks appears to be recorded in this category). This is clearly wholesale funding, as is anything recorded as bonds or notes (and which is not otherwise identified as subordinated debt). Beyond that, however, some component of banks' other deposits should normally be regarded as wholesale. Most banks, at least in the on-quarters,

[132] For Table 3, figures are as at 30 June 2003 or 30 September 2003, according to whichever was the relevant on-quarter date for disclosure. By 31 December 2003, the NBNZ's accounting practices were changing to conform to its acquisition by the ANZ. Figures have been derived from an examination of the banks' disclosure statements in each case.

identify certificates of deposit,[133] which can be presumed to be wholesale, but, particularly in off-quarters, it can be impossible to distinguish between wholesale and retail funding. With this reporting not reliable, it is difficult to distinguish between the effects of changes in funding mix and other factors on banks' cost of funds. It also makes it very difficult to report a standardised, coherent figure for deposits, which has generally been overcome in this research by using a very broad figure, such as all interest-bearing liabilities except subordinated debt.

Problems also arise in understanding how liquid a bank's liquid assets are. If a distinction is made between a bank's trading and investment securities, does this mean that the investment securities are less liquid, or is this just a reflection of the accounting policy applying to their revaluation? Without more detail as to what the liquid assets are, it is not known how liquid they really are (or whether their value is certain). From time to time, ANZ has shown significant values of shares in publicly listed companies among its trading securities, although when daily turnover on the New Zealand Stock Exchange rarely exceeds $200 million (and is often as low as $50 million), how can these assets really be liquid and at a certain price?[134]

4.2.3 Summary

The preceding chronicle of defects might make it seem as if the data provided in the New Zealand banks' quarterly disclosure statements could be unfit for use in further analysis. That would be an unreasonable conclusion, however. A fairer way to interpret that list of deficiencies would be to regard them as potential weaknesses in a useful data set. The data set is not perfect, but an appreciation of its weaknesses means that, if unusual or volatile results are obtained, there may be merit in examining the data as a potential cause.

The next section shows how this data can be used in this research.

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[133] Westpac used not to identify certificates of deposit, although sectoral information for New Zealand certificates of deposit was provided in notes to the financial statements for the parent bank. This disclosure has improved significantly in 2004.

[134] The discussion of market risk in the 30 September 2002 disclosure statements noted that the bank had entered into guarantee arrangements with its Ultimate Parent Company to eliminate most of the equity risk (and the market risk number reported in respect of the bank's equity holdings was therefore only $1million in respect of an equity portfolio of $347 million).

4.3 General methodological issues

A major methodological issue was in selecting the inputs and outputs to be used in the efficiency models. One approach followed in other studies has been to look at the totality of inputs and outputs used by banks in their role as financial intermediaries, and thus to use interest and non-interest expense as inputs, and net interest income and non-interest income as outputs (These data are readily available from a bank's consolidated financial statements). This sort of model provides a reasonable coverage of the range of resources utilised by banks (even if the breakdown is quite limited) and it will generally reflect all the revenues generated from use of these resources. Such a model was used by Avkiran (1999a), although in his alternative model he used deposits and staff numbers as inputs and net loans (instead of net interest income) as outputs.

An alternative input to non-interest expense, used in a number of previous studies, has been staff numbers. There is some question as to the appropriateness of staff numbers as an input, however, because of the increased level of outsourcing being undertaken by the banks, which means that staff numbers may not reflect the supply of staff resources to the banks' activities. In any case, non-interest expense covers a broader range of inputs into banks' production/intermediation processes.

An alternative output variable sometimes used is total loans, reflecting a bank's effectiveness in promoting financial intermediation. This takes no account of the returns being earned on those loans, however, and unless additional output variables are included to account for the remainder of the bank's assets, may provide a rather less than full accounting for the range of activities the bank undertakes.

The research sometimes avoids using interest expense as an input, using instead a figure for total deposits.[135] This is because, as Tripe (2003) has noted, interest expense is likely to be closely related to the general level of interest rates; if the research was looking at measuring efficiency across periods or locations where interest rates had

[135] The figure used thus includes both retail and wholesale deposits but not subordinated debt. It differs from figures for total interest-bearing liabilities in that it will also include some non-interest bearing deposits (as in non-interest bearing current accounts, New Zealand dollar balances in vostro accounts, etc).

varied, efficiency differences might be reported which were in fact spurious. The analysis reported in Tripe (2003) is repeated and an effort made to extend the results obtained as part of this research (See sections 4.4.2 and 5.2). Later in the research (sections 4.4.3 and 5.3) an examination is made of alternative proxies to measure the cost of funding that the banks use to sustain their intermediation process. It was noted (in Figure 1) that there has been some significant variation in the general level of interest rates, as reflected in the 90-day bill rate,[136] over the period of the study (1996 to 2003).

Leightner & Lovell (1998) provide a justification for using net interest income and non-interest income as outputs. The output characteristics of deposits, in terms of generating fee income, get to be included in outputs, whereas the costs involved in collecting these deposits can be incorporated in the inputs. They also note that using income-based outputs is closer to banks' profit-maximising goals than using quantity-based outputs.

Because the data set is large enough to allow it, the research also investigates the impact of including selected further input and output variables. In this regard, a key input variable that experimented with is equity capital, which is used in a number of the studies described in the next section. Berger & Mester (1997) provide support for its inclusion on the basis that it both provides an allowance for risk and constitutes a source of funding. Note that because Westpac has operated as a branch, it has not been required to hold any equity in its New Zealand business, and for the early part of the period studied, its equity levels were very low.

An additional output variable tested for is total off-balance sheet positions (other than those that are market risk related). This acknowledges previous research (reported in section 3.4.3), although regard is had for the comments by Siems & Clark (1997) on the potential impact of different ways in which off-balance sheet business is measured.

[136] The 90-day bill rate is considered to be a reasonable proxy for the general level of interest rates as the bank bill market is inclined to be banks' marginal source of wholesale funding. 90 days is also reported as being banks' most common maturity for liabilities, while the 90-day bill rate acts as a benchmark for pricing of both asset and liability products, as well as being used to price the floating rate leg of interest rate swaps.

Some previous research (e.g. Berger & DeYoung, 1997) has included measures of credit quality in banks' input/output sets. During the period of this study, New Zealand banks have had very little in the way of problem loans or related debt expense, and it is therefore not likely to be useful to incorporate these into the attempts at efficiency measurement in this research.

The appropriateness of input and output variables studies is in all cases tested for by looking at the correlations between inputs, between outputs, and between inputs and outputs. The research thus looks at correlations between non-interest income and total off-balance sheet positions, to make sure that they are not both measuring very similar effects.

As a further check for the consistency of the input and output variables used, an input-oriented constant returns to scale super-efficiency model was run for each data set in the study. This allowed identification of any DMUs which were outliers, and which ought to be omitted from the research. Consistent with the approach of Hartman et al (2001), a cut-off point of 2 was used for the super-efficiency score to identify outliers.

Because satisfactory price and quantity data are not available for all the input and output variables, this research is not able to assess allocative efficiency, and has thus been limited to measurement of technical efficiency. As Berger & Mester (1997) have noted, this leads to a focus on technological rather than economic optimisation, but such an approach is more common that not when DEA is used.

The time period used for most of the individual studies is 1996 to 2003. By 1996, most of the effects of deregulation had worked their way through both the New Zealand and Australian banking systems, and thus do not engender obvious distortions. In the New Zealand case, this also means that the results are not too much distorted by merger activity, in particular Westpac's acquisition of Trust Bank New Zealand in 1996, the NBNZ's acquisition of Countrywide in 1998, or the ANZ's acquisition of NBNZ in late 2003. This is sometimes achieved by omitting results for a particular period, as is noted in the outlines of individual studies in the next section.

The DEA software used for this set of studies is DEA-Solver, as described by Cooper et al (2000). In addition to offering an extensive range of DEA models, this also provides for calculation of scores for the Malmquist Index.[137]

4.4 The individual studies

4.4.1 Use of the cost to income ratio relative to multivariate approaches for measuring bank efficiency

The first of the studies undertaken as part of this research looks at reasons for using a multivariate approach to the measurement efficiency, rather than merely relying on the cost to income ratio. The analysis in this part of the study is undertaken in three stages. In the first stage the cost to income ratio is calculated for each bank for each period, with cost here defined as operating costs inclusive of depreciation and amortisation of goodwill, but not including bad and doubtful debt expense or extraordinary items. Income is gross income, defined as the total of net interest income and non-interest income.

The two remaining stages of this study look at the Malmquist Index for a cross-section of six banks, followed by a DEA analysis of the full panel of the same data, which gives an efficiency score for each bank for each year. Use of panel data in this way normally caries an implicit assumption that the period be short enough for individual DMUs not to be subject to technical change, allowing researchers to look at average efficiency for that DMU. This assumption is to some extent turned on its head so that the assumption of constant technology is not required: changes in efficiency scores may then be a reflection of technological change having occurred.

Annual data has been chosen to be used for this study, covering the period 1996 to 2003, during which time the average cost to income ratio for the 6 banks in the study declined from over 70% to below 50%. The two input variables used are non-interest expense and average total deposits (retail, wholesale and interbank, but not including

[137] At one stage the same data was run through both DEA-Solver and DEAP (developed by Tim Coelli and described in Coelli et al, 1998), and the same set of efficiency scores were obtained.

subordinated debt or equity).[138] with the latter item reflecting the funds being used in the intermediation process. Output variables used are net interest income and non-interest income. This will give efficiency measures which are not too conceptually different from the cost to income ratio – any differences in efficiency measures will then be a direct reflection of the multivariate approach being used.

Table 4: Descriptive statistics for inputs and outputs, study comparing Malmquist and DEA of panel data (with data from banks' disclosure statements)

1996	Deposits	Non Interest Expense	Net Interest Income	Non-Interest Income
Maximum	19193	724	681	428
Minimum	523	17	23	4
Average	12617	420	391	222
St Dev	6596	236	220	135
1997				
Maximum	23984	723	754	481
Minimum	609	19	26	5
Average	14447	453	455	248
St Dev	7621	253	250	157
1998				
Maximum	24077	723	836	418
Minimum	733	20	29	5
Average	16408	449	490	255
St Dev	8127	235	259	145
1999				
Maximum	25997	687	854	407
Minimum	906	22	32	7
Average	18599	445	519	279
St Dev	9106	224	268	149
2000				
Maximum	28400	713	865	498
Minimum	1062	22	35	7
Average	20050	464	548	318
St Dev	9577	233	274	175
2001				
Maximum	30983	649	829	494
Minimum	1206	24	42	7
Average	22103	457	594	329
St Dev	10476	218	276	180
2002				
Maximum	32677	685	977	522
Minimum	1395	24	45	7
Average	23507	472	667	348
St Dev	10847	223	317	186
2003				
Maximum	35110	699	1055	538
Minimum	1580	28	54	8
Average	24567	505	734	356
St Dev	11019	235	339	186

[138] This reflects difficulties in defining deposits, discussed in sub-section 4.2.2 above.

Summary statistics for the input and output data for each year are reported in Table 4. The correlations between the inputs, the outputs, and between the inputs and outputs are reported in Table 5. The correlation coefficients reported (from DEA-Solver) affirm that the variables used are not inappropriate, with the inputs and outputs not too highly correlated with each other, but with a reasonable correlation between the inputs and outputs such as would suggest that the inputs cause the outputs. The highest score under the super-efficiency model was 1.058, which suggests the absence of any outliers that would need to be omitted from the analysis.

Table 5: Correlations between input and output variables, study comparing Malmquist and DEA of panel data

	Non-interest expense	*Net interest income*	*Non-interest income*
Deposits	0.896	0.972	0.894
Non-interest Expense		0.925	0.938
Net interest Income			0.898

4.4.2 Efficiency trends through time

Tripe (2003) found problems with use of gross interest expense as an input variable in studies covering different time periods, with differences in financial institutions' interest costs inclined to reflect differences in the general level of interest rates, rather than differences in efficiency in raising deposits (or risk). The second of the studies undertaken as part of this research looks to replicate that research, and to ascertain if there are signals in the data that could have identified this problem at the outset.

For this study and those described in the next sub-section (4.4.3), initial studies were for the banks individually through time, and use was therefore made of quarterly data to try and ensure that there was a sufficiently large data set to provide meaningful efficiency scores (and thus meaningful trends). This provided 31 observations for three of the banks (ASB, BNZ and TSB), covering the period from the June quarter 1996 to the December quarter 2003. For the other three banks (ANZ, NBNZ and Westpac) there were 30 observations, with observations omitted because of figures being distorted by merger related effects (affecting the ANZ and NBNZ in the

December quarter 2003, and Westpac in the June quarter 1996).[139] Because essentially the same data was used for both this study and that outlined in the next section, the two data sets are reviewed and the relevant descriptive statistics are reported, together, in the next section.

Initial DEA analysis is undertaken using (gross) interest expense and non-interest expense as inputs, and net interest income and non-interest income as outputs. Once the set of efficiency scores has been generated for each bank, a test is undertaken for the relationship between those efficiency scores and the general level of interest rates, as reflected in the quarterly average 90-day bill rate (calculated from the monthly average 90-day bill rates from the Reserve Bank of New Zealand's web-site). The 90-day bill rate is generally a key interest rate in New Zealand financial markets, with 90 days being the most prevalent maturity for bank funding and as a basis for other pricing.

The testing was undertaken using logit regression, reflecting the truncation of bank efficiency scores at 1.[140] The logits were calculated in the standard way as:

$$Logit\ (E) = Log\ [E/(1-E)] \qquad (3)$$

where E represents the estimated efficiency score.[141] The logits were also tested against alternative explanatory variables of time (to see if apparent efficiency improvements might be a reflection of technical progress) and total assets (as a way of testing for scale effects). Time was measured as an index variable which increased by one for each quarter.

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[139] A potential point of concern is that results might be distorted because panels are not complete for the June quarter 1996 and the December quarter 2003. It is found that this has no impact on the efficiency scores, a result that would be expected as none of those points are on the efficient frontier for the all-bank models.

[140] Although Coelli et al (1998) recommend use of tobit regression, logit was used by Mester (1993, 1996). Tripe (2003) used OLS with the unadjusted efficiency scores as the response variable: interpretation of that approach requires dealing with estimated efficiency scores that are greater than one.

[141] In calculating the logits, it was necessary to subtract 0.0001 from the efficiency scores, as the logits of efficiency scores of 1 (for efficient firms) would otherwise have been undefined (at infinity).

4.4.3 Alternative input variables

That study was followed with an investigation of alternative choices of input variables in particular, which might get around some of the problems caused by movements in the general level of interest rates. The first stage of this follow-up is to add figures for shareholders' equity to those input variables used in the model in the previous section. In the second stage the gross interest expense variable was replaced with an adjusted interest expense variable, as described below.

There is a challenge in specifying a variable that reflects banks' utilisation of funds, but that is independent of the general level of interest rates. The adjusted interest cost variable that is used is constructed as follows, based on the interest expense figure as per the income statement and the reported total level of interest-bearing liabilities. A sum equivalent to the average annualised cost of funds for the six banks in the study,[142] less 2%, multiplied by the average level of interest bearing liabilities, is subtracted from the interest expense figure,[143] as follows:

$$\textit{Adjusted interest expense} = \textit{actual interest expense} - (\textit{all-bank adjustment } X \textit{ total interest-bearing liabilities}) \quad (4)$$

where all bank adjustment is defined as average interest cost (relative to interest-bearing liabilities, as an annualised percentage, across all 6 banks) less 2%.

This gives an adjusted interest expense figure from which variations in the general level of interest rates have been removed. The amount by which banks' interest costs exceed the adjusted level will reflect the cost and efficiency with which they raise funds, relative to other banks. Note, however, that the base (average) interest cost used in these calculations will be subject to the influence of competitive conditions in the banking market as a whole, insofar as these impact on banks' overall funding margin relative to a base cost of funds (such as the 90-day bill rate). This is a potential issue in interpreting the results obtained.

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[142] This average interest rate is used as the basis for determining interest cost as the obvious alternative, the 90-day bill rate, is inclined to move more quickly than banks' cost of funds. The margin between banks' cost of funds and the 90-day rate is therefore inclined to vary according to whether interest rates have been rising or falling. This effect is particularly evident in quarterly data.

[143] The 2% figure is somewhat arbitrary, but was chosen to ensure that the figure for cost of funds was always positive.

The research then examines the differences between the efficiency scores generated by the two different models (both with shareholders' equity as an additional input, but with gross interest expense and adjusted interest expense as alternative inputs). These results are compared with those generated from the model without equity as an input (as described in subsection 4.4.2).

As a next step in this analysis, total off-balance sheet positions (but not including interest and exchange rate derivatives) are included as an additional output variable.[144] Results from these analyses are compared with those obtained in the two sets of models described in the previous paragraph.

Consistent with the approach described in subsection 4.4.2 above, the analysis is undertaken in the first instance on an individual bank-by-bank basis, which allows a comparison of these results with those obtained previously. Descriptive statistics for the variables used for each of the banks for both these studies and those described in subsection 4.4.2 are reported in Table 6.

Table 6: Descriptive statistics – individual bank studies, compiled using data from banks' disclosure statements

ANZ ($M)	Minimum	Maximum	Mean	Standard Deviation
Interest Expense	198.97	383.05	302.25	41.85
Net interest income	117.74	199.00	157.78	20.33
Non-interest income	84.59	130.00	110.67	9.66
Adjusted interest expense	62.18	150.45	106.12	22.26
Non-interest expense	117.61	191.68	148.94	19.66
Equity	883.6	1555.0	1238.3	174.3
Off-balance sheet positions	6012.1	10989.1	7959.4	1117.1

ASB ($M)	Minimum	Maximum	Mean	Standard Deviation
Interest Expense	131.4	339.9	224.5	61.1
Net interest income	56.0	166.9	105.3	33.0
Non-interest income	25.5	66.9	45.1	10.2
Adjusted interest expense	31.7	139.6	77.8	33.5
Non-interest expense	56.7	107.8	82.4	14.1
Equity	451.9	1264.8	785.2	235.8
Off-balance sheet positions	1137	5091	2599	1219

[144] There are some alternative proxies to measure the impact of off-balance sheet business. Leong et al (2003) have measured off-balance sheet business by using total risk-weighted assets as an output. Initial investigations (not part of, and not reported in this dissertation) suggest that, for New Zealand banks, these show a stable relationship with total on-balance sheet assets, and that this approach might therefore not significantly augment discriminatory power.

BNZ ($M)	Minimum	Maximum	Mean	Standard Deviation
Interest Expense	245	479	397	48
Net interest income	142	247	184	24
Non-interest income	72	149	107	22
Adjusted interest expense	69	255	142	42
Non-interest expense	133	193	154	16
Equity	1035	2316	1557	396
Off-balance sheet positions	3503	5607	4435	531

NBNZ ($M)	Minimum	Maximum	Mean	Standard Deviation
Interest Expense	264	444	352	53
Net interest income	83	267	174	57
Non-interest income	41	104	74	17
Adjusted interest expense	60	197	125	33
Non-interest expense	97	166	128	17
Equity	920	2746	1774	567
Off-balance sheet positions	3091	9088	5466	2033

TSB ($M)	Minimum	Maximum	Mean	Standard Deviation
Interest Expense	8.9	17.8	13.0	2.9
Net interest income	6.0	14.4	9.9	2.6
Non-interest income	1.1	2.7	1.7	0.4
Adjusted interest expense	0.6	5.8	2.9	1.4
Non-interest expense	4.0	7.7	5.9	0.9
Equity	52.8	145.7	90.6	27.7
Off-balance sheet positions	59.3	224.7	127.2	48.7

Westpac ($M)	Minimum	Maximum	Mean	Standard Deviation
Interest Expense	248.5	485.9	367.8	63.6
Net interest income	168.6	267.0	215.9	26.6
Non-interest income	60.9	141.0	110.7	19.7
Adjusted interest expense	64.4	190.8	118.2	28.0
Non-interest expense	158.1	207.1	173.6	11.6
Equity	140.1	2953.5	1486.0	971.0
Off-balance sheet positions	6818	14385	9832	2233

Correlations between the input and output variables from both this set of studies and that described in the previous subsection are reported in Table 7. The highest super-efficiency score from any of these models was 1.31913. This gives no indication of the existence of outliers that would have to be removed from the analysis.

Table 7: Correlations between inputs and outputs – individual bank studies

ANZ	*Net interest income*	*Non-interest income*	*Adjusted Interest expense*	*Non-Interest expense*	*Equity*	*Off-balance sheet*
Interest expense	-0.160	0.061	0.224	0.169	-0.091	-0.264
Net interest income		0.311	0.587	-0.534	0.729	0.338
Non-interest income			0.142	0.136	0.145	0.042
Adjusted interest expense				-0.744	0.717	0.490
Non-interest expense					-0.550	-0.533
Equity						0.377

ASB	*Net interest income*	*Non-interest income*	*Adjusted Interest expense*	*Non-Interest expense*	*Equity*	*Off-balance sheet*
Interest expense	0.890	0.803	0.926	0.849	0.822	0.857
Net interest income		0.935	0.946	0.976	0.968	0.976
Non-interest income			0.905	0.947	0.958	0.967
Adjusted interest expense				0.934	0.913	0.930
Non-interest expense					0.951	0.965
Equity						0.974

BNZ	*Net interest income*	*Non-interest income*	*Adjusted Interest expense*	*Non-Interest expense*	*Equity*	*Off-balance sheet*
Interest expense	0.216	0.439	0.381	0.553	0.223	0.242
Net interest income		0.492	0.130	0.463	0.787	0.618
Non-interest income			0.724	0.445	0.801	0.867
Adjusted interest expense				0.308	0.507	0.703
Non-interest expense					0.296	0.344
Equity						0.884

NBNZ	*Net interest income*	*Non-interest income*	*Adjusted Interest expense*	*Non-Interest expense*	*Equity*	*Off-balance sheet*
Interest expense	0.657	0.623	0.705	0.482	0.723	0.793
Net interest income		0.893	0.767	0.769	0.985	0.886
Non-interest income			0.787	0.701	0.875	0.794
Adjusted interest expense				0.661	0.779	0.748
Non-interest expense					0.749	0.611
Equity						0.925

TSB	*Net interest income*	*Non-interest income*	*Adjusted Interest expense*	*Non-Interest expense*	*Equity*	*Off-balance sheet*
Interest expense	0.870	0.609	0.745	0.762	0.847	0.793
Net interest income		0.789	0.834	0.884	0.982	0.960
Non-interest income			0.769	0.733	0.828	0.833
Adjusted interest expense				0.729	0.876	0.875
Non-interest expense					0.885	0.872
Equity						0.989

Westpac	*Net interest income*	*Non-interest income*	*Adjusted Interest expense*	*Non-Interest expense*	*Equity*	*Off-balance sheet*
Interest expense	-0.270	-0.022	0.327	0.357	-0.214	-0.141
Net interest income		0.572	0.244	-0.032	0.680	0.469
Non-interest income			0.332	-0.162	0.796	0.637
Adjusted interest expense				-0.175	0.323	0.292
Non-interest expense					-0.397	-0.512
Equity						0.859

For some of the banks, ASB, NBNZ, TSB and to a lesser extent, BNZ, the correlation coefficients are consistent with expectations, in that inputs – interest expense, adjusted interest expense, non-interest expense and equity – are strongly positively correlated with the outputs, which supports the view that the inputs contribute to the outputs. Some of the lower correlations reported for these banks, such as between interest and non-interest expense and equity for the BNZ (0.223 and 0.296 respectively), are also consistent with the appropriate variables having been selected, in that the input variables are not too highly correlated with each other.

Against this background, the results obtained for ANZ and Westpac, where correlations are weaker and sometimes negative, are a little surprising. For example, for both banks, net interest income is negatively correlated with both total interest expense and non-interest expense. Although it is problematic for their inclusion in the same input/output set for an efficiency study, the negative correlation with total interest expense might be justified on the grounds that an objective of bank asset and liability management is to achieve stable levels of net interest income across the interest rate cycle, although even then one would expect a positive correlation as the values for both variables responded to changes in the size of the balance sheet.[145] The negative correlation between non-interest expense and net interest income makes no sense, however: one struggles to find a plausible argument as to why lower levels of non-interest expense might be associated with higher levels of net interest income.[146] It appears that there may be something unusual about these banks' results that might need to be explored further, although it is noted that these two banks have had some

[145] This might account for the relatively low correlation coefficient observed for BNZ. See Tripe (2002) for evidence supporting the proposition that banks' net interest margins are independent of the general level of interest rates.

[146] Attempts to investigate the apparent anomaly by looking at regressions of the input variables against the output variables (as response variables) provide no significant help, in that many of the input variables are found to have negative coefficients.

changes to accounting policy and practice over the period of the study. Adjustments to the period analysed might therefore generate correlation coefficients which were more consistent with expectations.

Another finding from the correlations is the merit of using adjusted interest expense as an input, rather than gross interest expense. The sum of the correlation coefficients for net interest income and non-interest income, relative to adjusted interest expense, is higher than the sum of the correlation coefficients for net interest income and non-interest income relative to gross interest expense. This suggests that the adjusted interest expense figure might be the more appropriate input.

It may also be noted that equity shows a relatively stronger correlation with the output variables, which provides support for its inclusion as an input. It also shows as not especially highly correlated with the other input variables, which means that its effect should be separately identifiable in the interpretation of efficiency scores.

A final step in this part of the analysis looks at all the banks together in a grand panel for each of the input and output combinations explored on a bank-by-bank basis. The correlation analyses for the inputs and outputs for all the banks together are reported in Table 8. These show that the inputs have a relationship with the outputs, and can thus be justified as contributing towards them. On the other hand, neither the inputs themselves nor the outputs themselves are so highly correlated with each other that their simultaneous inclusion in the models is redundant.

Table 8: Correlations between inputs and outputs, all banks together

	Net interest income	*Non-interest income*	*Adjusted Interest expense*	*Non-Interest expense*	*Equity*	*Off-balance sheet*
Interest expense	0.883	0.848	0.886	0.912	0.719	0.691
Net interest income		0.887	0.851	0.908	0.845	0.835
Non-interest income			0.825	0.926	0.780	0.841
Adjusted interest expense				0.799	0.780	0.660
Non-interest expense					0.690	0.805
Equity						0.729

The highest efficiency score reported by the super-efficiency model for all banks together was less than 1.32, and there is therefore no basis for identifying any DMUs as outliers requiring to be rejected from the analysis.

It is not until an analysis of all banks together is undertaken using DEA that an assessment can be made of banks' efficiency relative to each other.

4.4.4 An introductory cross-country study

The final set of studies undertaken looks at the relative efficiencies of banks with significant retail branch networks in Australia and New Zealand, with the Australian banks sub-classified into the major and regional banks. Two separate models are used, with the inputs and outputs recorded in Table 9.

Table 9: Inputs and outputs – cross-country study

	Model 1	Model 2
Inputs	Total deposits Non-interest expense Equity capital	Total deposits Non-interest expense
Outputs	Net interest income Non-interest income	Net interest income Non-interest income

This study has used total deposits (retail, wholesale and interbank, but not including subordinated debt or equity) as an input, to reflect the funds being used in the intermediation process. Note also that this choice of total deposits has to some extent been forced by the differences in the way individual banks classify their interest-bearing liabilities. The research has avoided using an interest expense variable because of the differences in the general level of interest rates across the period of the study, and between the two countries whose banks are having their performance compared.

The study uses panel data covering an 8-year period from 1996 to 2003 (inclusive) for the 15 banks included. For New Zealand, this covers the period from the introduction of the disclosure regime in 1996, up to the point of the ANZ's acquisition of the NBNZ in late 2003. Apart from some mergers, the time period covered has been a period of relative stability for both the Australian and New Zealand banking markets:

the relevant Australian regional banks had all converted to bank status prior to the period of the study, while the major banks had also recovered from the worst effects of their loan losses in the early 1990s.

Because of concerns over the differing levels of capital between Australia and New Zealand, which may reflect differences in banks' exposure to risk, but also because of the lack of any specific capital requirement for Westpac NZ, equity capital has been included as an input in the first model that is used.

Descriptive statistics on the input and output data used are reported in Table 10. It is apparent that the major Australian banks are much larger than either the New Zealand banks or the Australian regional banks, which are similar in size to each other.

Table 10: Statistics on input data (in AUD) – cross-country study (complied using information from banks' annual figures).

All banks	*Deposits*	*Equity*	*Non Interest Expense*	*Net Interest Income*	*Non-Interest Income*
Max	282257	25231	8808	7419	7219
Min	468	43	15	20	4
Average	46645	3950	1436	1489	995
SD	60199	5857	1979	1901	1531
Australian majors					
Max	282257	25231	8808	7419	7219
Min	70436	6042	2905	3254	1488
Average	134747	12294	4380	4425	3148
Australian regionals					
Max	48975	4102	1430	1451	910
Min	1637	105	66	69	21
Average	12818	950	337	367	168
New Zealand banks					
Max	31395	2365	643	943	483
Min	468	43	15	20	4
Average	16100	887	389	466	249

The correlations between the inputs, the outputs, and between the inputs and outputs are reported in Table 11. These show that the inputs have a relationship with the outputs, and can thus be justified as contributing towards them. On the other hand, neither the inputs themselves nor the outputs themselves are so highly correlated with each other that their simultaneous inclusion in the models is redundant. The highest super-efficiency score from either of the models is 1.188, which suggests that there is no problem with outliers requiring DMUs to be omitted.

Table 11: Correlations between inputs and outputs – cross-country study

	Equity	*Non-interest expense*	*Net interest income*	*Non-interest income*
Deposits	0.9794	0.9804	0.9840	0.9802
Equity		0.9768	0.9654	0.9815
Non-interest expense			0.9860	0.9852
Net interest income				0.9658

There are four parts to the analysis undertaken in this section. The first part looks at the question of whether it is appropriate to apply a common frontier to these three groups of banks, operating in two different countries. Although all the banks in the study operate through significant branch networks, and although in the case of the Australian major banks the study looks at both their global operations and at the New Zealand business on a stand-alone basis, this question cannot be answered a priori. To explore this particular question a panel comprising just the four major Australian banks is examined first, and the other banks are then added to that panel to see whether a common frontier appears to apply.[147]

For the remaining three parts of this analysis it is assumed that it is reasonable to apply a common frontier. Part 2 of the analysis looks at the efficiencies across the whole data set using Model 1 (as per Table 9), while the third part of the analysis looks at the results obtained from using Model 2. Differences in efficiency between the groups are explored using the non-parametric Mann-Whitney test. The final part of the analysis looks at the differences between the efficiency scores generated by the two different models in the previous two parts, using a technique similar to what Schaffnit et al (1997) refer to as spread ratios, and seeks to interpret those differences.

4.5 Summary

This chapter has reviewed the data to be used for this research and some of the issues that arise from them, as well as looking at the methods used for the four separate pieces of analysis that follow in the next chapter. It has shown that there is considerable depth in the information provided in New Zealand banks' disclosure

[147] This technique bears some similarity to that used by Berg et al (1992) to investigate trends in Norwegian bank efficiency through time.

statements, even if the inconsistencies in data presentation sometimes undermine its usefulness. Despite this, however, it is possible to conduct analyses using quarterly data, although for some purposes, annual data may be more appropriate.

5. Results

This research is structured in layers, as a series of questions, which generally derive from the results of a preceding piece of analysis. This chapter looks at those individual questions, at the analysis undertaken in an attempt to answer them and then reports on the results obtained. A summary reflection on these issues is provided in the final chapter.

The first of the issues explored is the rationale for use of a multivariate approach for the measurement of bank efficiency, rather than merely relying on use of a single ratio such as the cost to income ratio. This discussion also explores the use of different techniques for measuring efficiency change through time. The dissertation then explores in greater depth an issue highlighted in Tripe (2003), in respect of the way efficiency scores can be impacted by differences or changes in environmental variables (such as the general level of interest rates). This leads to an investigation of effects of using different input variables on efficiency scores, which starts off by looking at banks individually, and then looks at them together in a grand panel.

The final section of this chapter reports an examination of the relative efficiency of some New Zealand and Australian banks. A major part of this exercise is to justify looking at the banks together relative to the same frontier.

All of these pieces of analysis work towards answers to the questions posed in the first chapter of this dissertation. Have New Zealand banks become more efficient through time as they have reduced their costs? Does the profitability of New Zealand banks relate to their efficiency? In the final part of this chapter an attempt is made to explore some of the implications of the foreign ownership of the New Zealand banking system.

5.1 Use of the cost to income ratio to measure bank efficiency

The apparent improvement in Australia and New Zealand banks' cost to income ratios was highlighted in Chapter 2 (Figure 1). The trend in cost to income ratios for the New Zealand banks that are the prime focus of this research for the period 1996 to 2003 is reported in Table 12. The final line of the table records the aggregate improvement achieved, with this calculated as the change in cost to income ratio since 1996 divided by the cost to income ratio in 2003. The key point to note is that all the banks appear to have achieved significant improvements in their cost to income ratios, even though the ratio for the NBNZ in 2003 appears to be distorted upwards by additional costs relative to its acquisition by the ANZ.

Table 12: Cost to Income ratios for New Zealand banks (compiled using information from the banks' disclosure statements).

	ANZ	ASB	BNZ	NBNZ	TSB	Westpac
1996	72.7%	65.5%	60.8%	76.8%	61.0%	68.6%
1997	71.3%	63.7%	55.8%	67.8%	60.7%	64.9%
1998	62.5%	61.8%	59.4%	62.0%	59.1%	57.7%
1999	56.6%	60.6%	55.3%	52.6%	55.0%	56.4%
2000	55.8%	58.9%	54.8%	46.9%	52.2%	53.9%
2001	46.4%	54.5%	52.0%	46.9%	48.2%	49.7%
2002	44.9%	51.3%	45.9%	43.9%	45.2%	48.7%
2003	46.1%	47.9%	45.4%	47.7%	45.5%	44.5%
Improvement achieved	57.8%	36.8%	33.9%	61.1%	34.3%	54.2%

This is the background against which the improvements in efficiency can be assessed relative to those determined according to the Malmquist Index, and according to DEA analysis of panel data.

5.1.1 The Malmquist Index approach

The results from the Malmquist Index calculation are presented below. Figures for changes in pure technical efficiency (catch-up), technical change (frontier shift), and total factor productivity for each bank for each year, together with the average for each year, are reported in Table 13. The final column of the table reports the total effect over the 8-year period.

The average value of changes across the whole period, for catch-up, is 0.9970, equivalent on average to no change in pure technical efficiency (although the NBNZ and Westpac both show significant improvement). All banks have shown productivity-enhancing frontier shifts, with an overall average of 1.1436, although this change was greatest for ASB and least for TSB. In terms of total factor productivity, the average improvement was 1.1408, equivalent to a 14% improvement over the 7 years. Once again there are significant differences between banks, with major improvements for NBNZ and Westpac, and a notable decline for ANZ.

Because the Malmquist Index used here is a nonparametric approach which takes no account of random error, it is therefore regarded as prudent to report some further results for partial periods, where particular results might be regarded as unusual.

Table 13: Results from application of Malmquist Index – annual data for New Zealand banks

Year Ended	1997[148]	1998	1999	2000	2001	2002	2003	Total
Change in pure technical efficiency (catch-up)								
ANZ	1.01887	0.79715	0.97051	0.96054	1.14506	0.96882	0.89559	0.75223
ASB	0.95548	1.00178	0.97756	0.98769	1.0047	0.98479	1.02948	0.94136
BNZ	1.03982	0.84656	1.09333	1.01551	0.84216	1.06899	1.09327	0.96193
NBNZ	1.02219	1.01932	1.23294	1.04365	0.93805	1.00917	0.90042	1.1428
TSB	0.96006	1.01343	0.92502	1.03865	1.07576	0.90500	1.03724	0.94396
Westpac NZ	1.05567	1.21927	0.96873	1.01207	0.87664	1.00646	1.11361	1.23992
Average	1.00868	0.98292	1.02802	1.00968	0.98040	0.99054	1.0116	0.99703
Technical change (frontier shift)								
ANZ	0.99345	1.03993	1.02782	1.05025	1.03624	1.05539	0.99884	1.15471
ASB	1.03756	0.98455	0.99004	1.02313	1.05531	1.01768	1.02848	1.23306
BNZ	1.02383	1.03088	1.01222	1.06428	1.17447	1.06712	0.92663	1.11448
NBNZ	1.02466	0.98239	1.00440	1.05063	1.04488	1.06013	1.01548	1.14771
TSB	1.01850	0.97903	1.02313	0.98935	1.03592	1.04735	0.99143	1.04875
Westpac NZ	1.03835	0.95841	1.00387	1.00023	1.06515	1.03054	1.01334	1.16289
Average	1.02273	0.99586	1.01025	1.02964	1.06866	1.04637	0.9957	1.1436
Total factor productivity change								
ANZ	1.01219	0.82897	0.99751	1.00880	1.18656	1.02248	0.89455	0.86861
ASB	0.99137	0.98630	0.96782	1.01053	1.06027	1.00221	1.05880	1.16076
BNZ	1.06460	0.87270	1.10669	1.08078	0.98909	1.14074	1.01305	1.07206
NBNZ	1.04740	1.00136	1.23837	1.09648	0.98015	1.06984	0.91436	1.31160
TSB	0.97782	0.99218	0.94642	1.02759	1.11440	0.94785	1.02835	0.98998
Westpac NZ	1.09616	1.16856	0.97248	1.01230	0.93375	1.03720	1.12846	1.44189
Average	1.03159	0.97501	1.03822	1.03941	1.04404	1.03672	1.00626	1.14082

[148] This series of results starts in 1997, which measures the change since 1996.

In respect of pure technical efficiency, the largest individual positive changes were for Westpac in 1998 and the NBNZ in 1999. These are the financial years when these banks were showing the greatest improvement in performance as they consolidated, following the acquisition of Trust Bank New Zealand and Countrywide Bank respectively.[149] By contrast, the largest negative change was for ANZ in 1998: this was a year of significant restructuring for the bank as it sought to reduce costs, with there also being some changes in accounting policy and practice.[150] However, for the period 1998 to 2003, for the ANZ, there was a negative movement in pure technical efficiency, with a value for catch-up of 0.9262.

The technical changes arising from frontier shifts vary less, and overall effects are generally less significant. The largest individual changes are for the BNZ, upward in 2001 and downward in 2003. Reasons for this result are not obvious, and it is noted that pure technical efficiency changed in the opposite direction in the same periods, limiting the overall impact on total factor productivity. It could be that the reliability of the results has been impacted by the small size of each individual year's cross-section.

If we look at the average technical change across all banks, we see that change effects were strongest in 2001 and 2002. The most likely explanation for this would be that this was when banks were achieving the benefits of investment in internet technology, with increased customer adoption of the internet for account inquiries and transactions, and much more extensive use of intranets within the banks for communication, training, etc.

A review of the overall results for total factor productivity highlights the strong improvements achieved by NBNZ and Westpac, reflecting their improvements in technical efficiency, and the negative outcome for the ANZ, again reflecting the trend in its technical efficiency. Although industry expectations would be likely to be comfortable with these results for NBNZ and Westpac, they might not be so

[149] This is consistent with the findings of Liu & Tripe (2002), although the approach followed there looked only at relative efficiency scores for each year in isolation.

[150] This change in accounting policy and practice resulted in a significant reduction in reported non-interest income and thus in gross income. The consequences of this are discussed further in section 5.3.5

comfortable with the results obtained for the other banks (and with those for the ANZ in particular). To understand more about strengths and weaknesses in performance at an individual bank level, and to compare banks' efficiencies relative to each other, a further analysis of their efficiencies was undertaken in a panel using DEA, discussed in the next sub-section.

When the results from the application of the Malmquist Index are compared with others reported in prior research, concerns arise over the size of the cross-sections, and whether these are large enough to meaningfully distinguish total factor productivity trends between banks. This concern arises in respect of research by Noulas (1997) and Drake (2001), and is the subject of some discussion by Asmild et al. (2004). It is probable that the same rules of thumb in relation to sample size ought to be applied to use of the Malmquist Index as are used in other DEA analysis (as discussed in section 3.3 above).

5.1.2 The panel data approach

Efficiency scores for each bank for each year from the panel data analysis are reported in Table 14, with the trends through time highlighted in Figure 6. These results show a different picture, although they are broadly consistent with those derived using the Malmquist Index. An important aspect of this is the ability within a standard DEA approach to review the performance of inefficient units relative to their peers, and to identify the specific sources of inefficiency.

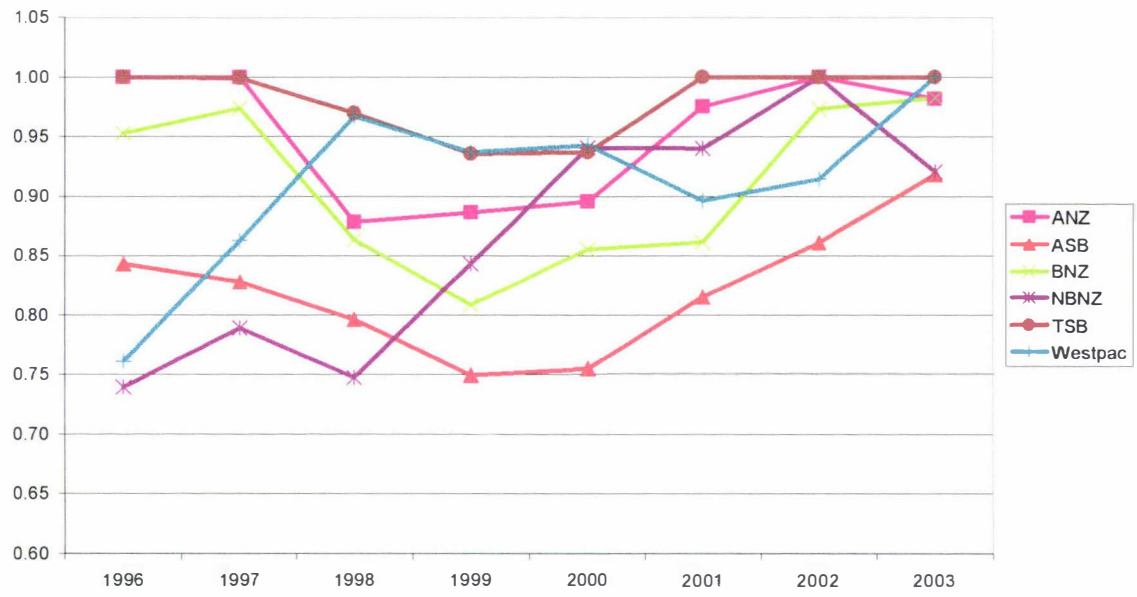
Table 14: Results from panel data analysis – annual data for New Zealand banks

Efficiency scores for year	ANZ	ASB	BNZ	NBNZ	TSB	Westpac	Average
1996	1.0000	0.8431	0.9527	0.7397	1.0000	0.7613	0.8828
1997	1.0000	0.8280	0.9739	0.7892	0.9991	0.8627	0.9088
1998	0.8786	0.7965	0.8638	0.7480	0.9700	0.9670	0.8706
1999	0.8862	0.7499	0.8088	0.8433	0.9355	0.9366	0.8601
2000	0.8954	0.7549	0.8556	0.9405	0.9369	0.9423	0.8876
2001	0.9753	0.8154	0.8615	0.9400	1.0000	0.8961	0.9147
2002	1.0000	0.8607	0.9733	1.0000	1.0000	0.9140	0.9580
2003	0.9818	0.9183	0.9824	0.9205	1.0000	1.0000	0.9672
Average	0.9522	0.8208	0.9090	0.8652	0.9802	0.9100	

The panel data show that the most efficient banks overall were TSB and ANZ. These were the ones to show negative changes in total factor productivity (although only to a

very limited extent in TSB's case), with the ANZ showing a particularly negative result for pure technical efficiency. The least efficient bank overall was ASB, which also showed a negative effect overall on technical efficiency from the Malmquist Index, although this was compensated for by positive technical change. Nothing can be discerned from these results to explain the changes in different aspects of the BNZ's productivity in 2001 and 2003, attention to which was drawn in the previous sub-section.

Figure 6: Efficiency scores through time - New Zealand banks



In comparing these results with those from the Malmquist Index study, it can be seen that the major improvement in efficiency for the NBNZ and Westpac appear to be at least in part a reflection of their relative inefficiency at the start of the period studied. By the end of the period their efficiency had largely converged (the downturn for the NBNZ in 2003 is likely to reflect additional operating costs, at least in part reflecting accounting adjustments, incurred in relation to its acquisition by the ANZ). The DEA projections for these two banks show that the inefficiency in the earlier part of the period studied was attributable to an over-utilisation of inputs, and the overall inefficiency is consistent with a major part of these banks' improvement (as per the Malmquist Index approach) being catch-up, rather than frontier shift.

As a further check on the results from the panel data approach, a variable returns to scale model was run to test for scale effects, and to explore the popular belief amongst

bank management that there are benefits from increased asset values. The average scale efficiency reported was 0.9883, which suggests that scale benefits were not important. Returns to scale indicators were either constant (29 cases) or decreasing (19 cases), casting further doubts on the likelihood of increasing returns to scale. It is also noted that TSB Bank, which was by far the smallest of the banks in the study, was most efficient under the original constant returns to scale model.[151] Even if there are some questions as to the reliability of the results in respect of returns to scale, there is no evidence of the existence of benefits from increasing scale.[152] This is, of course, contrary to the generally expected views of bank managements.

5.1.3 Discussion

This section has looked at two different approaches to try and assess changes in New Zealand bank efficiency over time, and also at figures for the cost to income ratio for each bank over the period. The challenge now is to try and reconcile these results.

To reconcile the two sets of results, it must first be remembered that the Malmquist Index is only measuring changes in productivity, rather than its absolute level. To compare results from use of the Malmquist Index with those from the DEA panel data study, it was therefore necessary to look at the way the efficiency scores derived from the panel data changed for each bank over the period of the study.

Table 15: Relative changes in banks' efficiency scores, based on panel data results

Change, relative to previous year	*ANZ*	*ASB*	*BNZ*	*NBNZ*	*TSB*	*Westpac*
1997	1	0.982134	1.022182	1.066949	0.999143	1.133219
1998	0.878591	0.961962	0.88693	0.947811	0.970872	1.120845
1999	1.008699	0.941461	0.936396	1.127451	0.964422	0.968617
2000	1.01034	1.006718	1.057805	1.115272	1.001483	1.006059
2001	1.089226	1.080166	1.006901	0.999413	1.067334	0.950947
2002	1.025337	1.055517	1.129745	1.06384	1	1.020011
2003	0.981834	1.066885	1.009438	0.920514	1	1.094051

[151] Average scale efficiency for TSB was 0.991.

[152] As a further example of the potential unreliability of the reported scale effects, results for the NBNZ from the variable returns to scale model for 2003 show all the inefficiency as being attributable to scale. In fact, because of its acquisition by the ANZ, there were a number of unusual or additional costs (which are not adjusted for because of less than full information as to their amount), and these are likely to have contributed significantly to the inefficiency reported in the constant returns to scale model.

Table 15 reports efficiency change scores as per the DEA panel data study, which should be akin to the changes in total factor productivity reported by the Malmquist Index, relative to the previous year, for each bank, for the years 1997 to 2003.

This set of scores is remarkably similar to the total factor productivity scores generated from the Malmquist Index calculation, shown in the bottom panel of Table 13. The average difference between the two sets of scores is calculated at 1.008 (0.8%). In most cases, a negative (positive) movement in the efficiency scores generated from the panel data is associated with a total factor productivity decline (improvement), as estimated from the Malmquist Index.

This result should be no surprise. Both approaches are comparing the utilisation of the same inputs and outputs in different time periods, with the difference lying only in the way the Malmquist Index seeks to break efficiency changes down into changes in individual firm efficiency and technical change applying to the whole banking sector. In such a context, the strength of the Malmquist Index is that it allows some assessment of the nature of efficiency improvements, whereas the DEA analysis of panel data allows one to make some assessment of the sources of inefficiency in individual banking firms in the relevant periods.

The other point to be explored is the relationship between the efficiency improvements derived from the multivariate studies (both the Malmquist Index and DEA approaches), and the improvements in the cost to income ratio for each of the banks, as reported in the bottom row of Table 12.

The apparent improvements in the cost to income ratio are much greater than the improvements in the total factor productivity, as determined using the Malmquist Index,[153] and there is no particularly close relationship between the way banks score in terms of cost to income ratio improvement and the way they score in terms of total factor productivity improvement.

[153] The relevant comparative figures for the Malmquist Index are shown in the rightmost column of Table 13, with the figures in the third panel being most relevant to the current discussion.

The difference relates to the input and output variables considered, and most particularly in the way in which the cost to income ratio takes no account of banks' utilisation of funds.[154] These are an economic resource that banks are using, and if a meaningful view is to be gained of the efficiency with which banks utilise resources, those resources need to be taken into account. The lesser improvement in total factor productivity, relative to that suggested by improvement in the cost to income ratio, suggests that banks have been trading off non-interest expense for increased utilisation of funds, and that this increase in utilisation of funds has only been partly reflected in increased levels of net interest income and non-interest income.

Some of the issues raised in this section will be canvassed again as part of the review efficiency trends for all banks, based on quarterly data, in section 5.3. In the meantime, the remainder of the study concentrates on use of DEA of panel data, as that seems to be able to tell more about the causes of individual bank inefficiency in particular time periods.

5.2 Efficiency trends through time

5.2.1 DEA with gross interest expense as an input

The results obtained from this set of studies are generally consistent with those reported by Tripe (2003), in that individual banks' efficiency scores appear to increase through time, with peak efficiencies reported in the June quarter 1999 (when interest rates achieved an historic low) and then again since 2001 (when interest rates were again generally low). The relative efficiency scores are reported in Table 16.

[154] Note that a DEA model with one input (cost) and one output (income) should be expected to produce results very similar to those provided by the cost to income ratio (although optimal performance would then show an efficiency score of 1). Seen in this light, a multiple input/multiple output model should provide a superior perspective on financial institution efficiency.

Table 16: Efficiency scores for studies of individual banks – gross interest expense as an input (Constant returns to scale)

	ANZ	ASB	BNZ	NBNZ	TSB	Westpac
Jun-96	0.75359	0.97080	0.81924	0.60469	0.81468	
Sep-96	0.69868	0.73801	0.74819	0.64907	0.74826	0.55158
Dec-96	0.69728	0.92238	0.79490	0.71642	0.77226	0.61806
Mar-97	0.81539	0.93976	0.83271	0.68115	0.63335	0.63999
Jun-97	0.85938	0.84135	0.87991	0.71275	0.86494	0.70175
Sep-97	0.90667	0.81488	0.82678	0.62042	0.75513	0.74224
Dec-97	0.66496	0.82255	0.83440	0.61667	0.78443	0.76842
Mar-98	0.65401	0.79906	0.73595	0.66536	0.74088	0.71692
Jun-98	0.67545	0.72414	0.81245	0.66081	0.82961	0.76331
Sep-98	0.88957	0.81691	0.68362	0.69639	0.91955	0.80636
Dec-98	0.81534	0.90622	0.79218	0.76098	1	0.78307
Mar-99	0.89867	1	0.89708	1	0.91924	0.97908
Jun-99	1	1	1	0.98207	1	0.90290
Sep-99	0.99535	0.9739	0.70818	0.95312	0.98315	1
Dec-99	0.91560	1	0.84366	0.93319	1	0.93659
Mar-00	0.86410	0.99692	0.82366	0.89487	0.95566	0.89414
Jun-00	0.85841	0.91834	0.81170	0.97133	0.97832	0.86726
Sep-00	0.75652	0.88153	0.88718	0.78958	0.97909	0.87327
Dec-00	0.84422	0.91016	0.81864	0.87614	0.95148	0.82547
Mar-01	0.92791	0.84110	0.82015	0.89012	0.79321	0.80549
Jun-01	1	0.97498	0.79121	0.92367	0.96547	0.84408
Sep-01	1	0.90483	0.79160	0.93235	0.91081	1
Dec-01	0.98190	0.99326	0.85769	0.88966	1	0.96217
Mar-02	1	1	0.95145	1	0.98560	0.85459
Jun-02	0.99846	1	1	1	1	0.95023
Sep-02	0.95969	0.96258	0.91305	0.95032	1	1
Dec-02	0.95321	0.97477	0.96095	0.92432	0.94737	1
Mar-03	0.97657	0.99520	1	0.97518	0.91410	1
Jun-03	0.98201	1	1	1	0.99188	1
Sep-03	1	0.98685	0.94750	0.93341	0.98146	0.89754
Dec-03		1	0.93226		0.96744	0.98168
Average	0.87810	0.92292	0.85536	0.84014	0.90604	0.85554

These results are summarised in Figure 7, from which it would be easy to conclude that there had been an improvement in efficiency through time, either because of technical progress, or because growth in the banks' assets through time was making them more scale efficient.[155]

The potential impact of technical change was reviewed in section 5.1 above, although with a different set of inputs and outputs, and some evidence was found for it, but only for some banks. It would not be likely to be the only explanation for the trends observed in Figure 7. This data set was tested for scale effects, using the variable

[155] Note that the differences in the average scores for each bank cannot be construed as measures of relative efficiency between banks, but only of differences in the variability of each bank's efficiency. This is because a separate efficient frontier is being applied to each bank.

returns to scale model, with the results reported in Table 17, and also shown in Figure 8.

Table 17: Efficiency scores for studies of individual banks – gross interest expense as an input (Variable returns to scale)

	ANZ	ASB	BNZ	NBNZ	TSB	Westpac
Jun-96	0.754704	1	0.985185	0.893442	1	
Sep-96	0.737941	0.975247	0.786982	0.871735	0.894964	0.763399
Dec-96	0.703449	0.953336	0.875	0.909623	0.935835	0.886211
Mar-97	0.816778	1	0.956835	1	0.857658	0.899317
Jun-97	0.912304	0.927979	0.925257	0.991372	0.974686	0.869231
Sep-97	0.968845	0.921667	0.847536	1	0.883428	0.860776
Dec-97	0.773422	0.93884	0.910959	0.948982	0.862568	0.848369
Mar-98	0.787289	0.990552	0.898649	0.977228	0.853055	0.84365
Jun-98	0.79469	0.923694	0.956835	0.936332	0.915008	0.906017
Sep-98	1	0.931178	0.773256	0.851096	0.96376	0.903369
Dec-98	0.864276	0.931377	0.923611	0.841779	1	0.888026
Mar-99	1	1	0.985185	1	0.986321	1
Jun-99	1	1	1	1	1	0.986654
Sep-99	1	1	0.841772	1	1	1
Dec-99	0.929295	1	0.904762	0.954173	1	1
Mar-00	0.910827	1	0.910959	1	0.955791	0.952206
Jun-00	0.915974	0.93009	0.880795	1	1	0.96251
Sep-00	0.768977	0.921898	1	0.930701	1	0.966972
Dec-00	0.887802	0.928502	0.863636	0.894477	0.986043	0.943881
Mar-01	0.962939	0.918714	0.852564	0.967857	0.796345	0.969344
Jun-01	1	1	0.821142	0.988297	0.988585	0.988743
Sep-01	1	0.927557	0.793953	0.943005	0.933003	1
Dec-01	0.984974	1	0.882768	0.899789	1	0.963819
Mar-02	1	1	0.985019	1	0.993593	0.999368
Jun-02	1	1	1	1	1	1
Sep-02	0.963293	0.970788	0.979342	0.963889	1	1
Dec-02	0.959702	0.98358	1	0.982305	0.970042	1
Mar-03	0.980374	1	1	0.983573	0.919115	1
Jun-03	0.984556	1	1	1	1	1
Sep-03	1	0.988164	1	0.953479	1	0.92986
Dec-03		1	0.974601		1	1
Average	0.91208	0.969779	0.91989	0.956104	0.95709	0.944391

The estimated scale efficiencies derived from comparing the constant and variable returns to scale models are reported in Table 18.

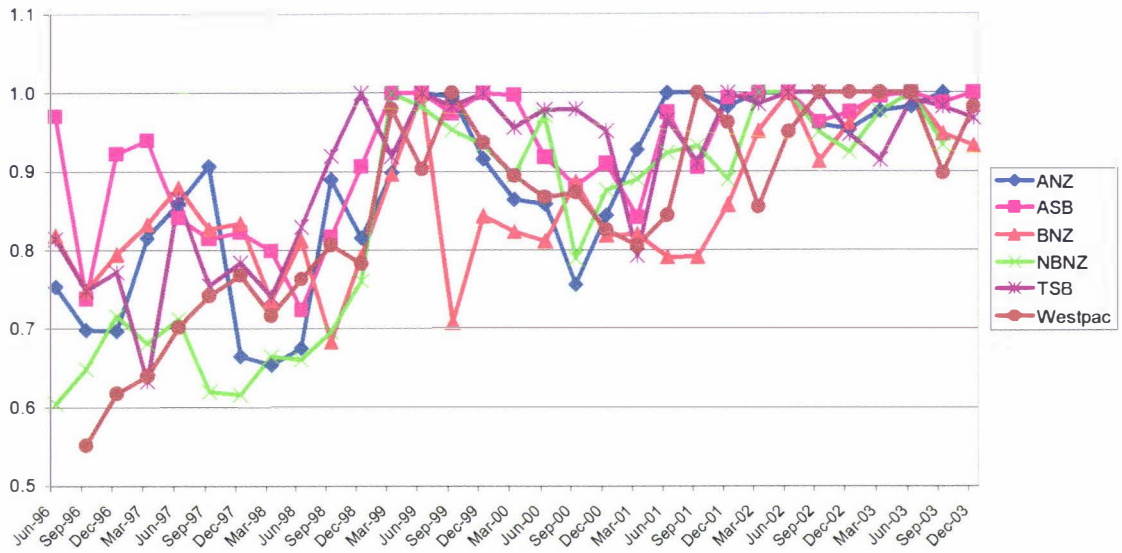
The variable returns to scale model shows significantly higher efficiency scores overall, and this is reflected in the estimates of scale inefficiency. This suggests that much of the inefficiency reported in the constant returns to scale model (reported in Table 16) can be attributed to scale effects. The results would also suggest that, once allowance is made for scale, there is rather less evidence of improvement in pure technical efficiency, such as might be construed as being a consequence of advances

in the technology being utilised. This conclusion is also supported by comparing Figure 7 with Figure 8. The improvement in efficiency is no longer evident to the same extent, although there is a suggestion that all the banks managed to be most efficient during 2002 and 2003.

Table 18: Estimated scale efficiency scores for studies of individual banks – gross interest expense as an input

	ANZ	ASB	BNZ	NBNZ	TSB	Westpac
Jun-96	0.998524	0.970801	0.831556	0.676812	0.81468	
Sep-96	0.946792	0.756743	0.950703	0.744569	0.836075	0.722529
Dec-96	0.991234	0.96753	0.908452	0.7876	0.825214	0.697422
Mar-97	0.998294	0.939759	0.870273	0.681147	0.73846	0.711643
Jun-97	0.941992	0.906652	0.950991	0.718949	0.887404	0.807318
Sep-97	0.93583	0.884132	0.975507	0.620415	0.854767	0.86229
Dec-97	0.859768	0.876132	0.915953	0.649826	0.909416	0.905764
Mar-98	0.830714	0.806677	0.818952	0.680865	0.868496	0.849779
Jun-98	0.84995	0.783956	0.849097	0.705745	0.906664	0.842492
Sep-98	0.889567	0.877288	0.884081	0.818233	0.954131	0.892615
Dec-98	0.943373	0.972989	0.857695	0.90401	1	0.881804
Mar-99	0.898672	1	0.910564	1	0.931991	0.97908
Jun-99	1	1	1	0.982068	1	0.915117
Sep-99	0.995345	0.9739	0.841295	0.953115	0.983145	1
Dec-99	0.985263	1	0.932469	0.978005	1	0.936588
Mar-00	0.948699	0.996921	0.904172	0.894873	0.999864	0.939015
Jun-00	0.937154	0.987364	0.921555	0.971331	0.978316	0.901037
Sep-00	0.983796	0.956216	0.88718	0.848366	0.979088	0.903099
Dec-00	0.950907	0.980242	0.947893	0.979502	0.96495	0.87455
Mar-01	0.96362	0.915522	0.961977	0.919683	0.996071	0.830961
Jun-01	1	0.974977	0.963549	0.93461	0.976618	0.853688
Sep-01	1	0.975495	0.997041	0.988705	0.976212	1
Dec-01	0.996881	0.993256	0.971586	0.988744	1	0.998285
Mar-02	1	1	0.965919	1	0.991956	0.85513
Jun-02	0.998455	1	1	1	1	0.950232
Sep-02	0.996262	0.991539	0.932309	0.985925	1	1
Dec-02	0.993239	0.991045	0.960954	0.940973	0.97663	1
Mar-03	0.996115	0.995197	1	0.991469	0.994547	1
Jun-03	0.997415	1	1	1	0.991877	1
Sep-03	1	0.998673	0.947504	0.978954	0.981456	0.965241
Dec-03		1	0.956555		0.967436	0.981684
Average	0.960929	0.950742	0.929541	0.877483	0.944692	0.901912

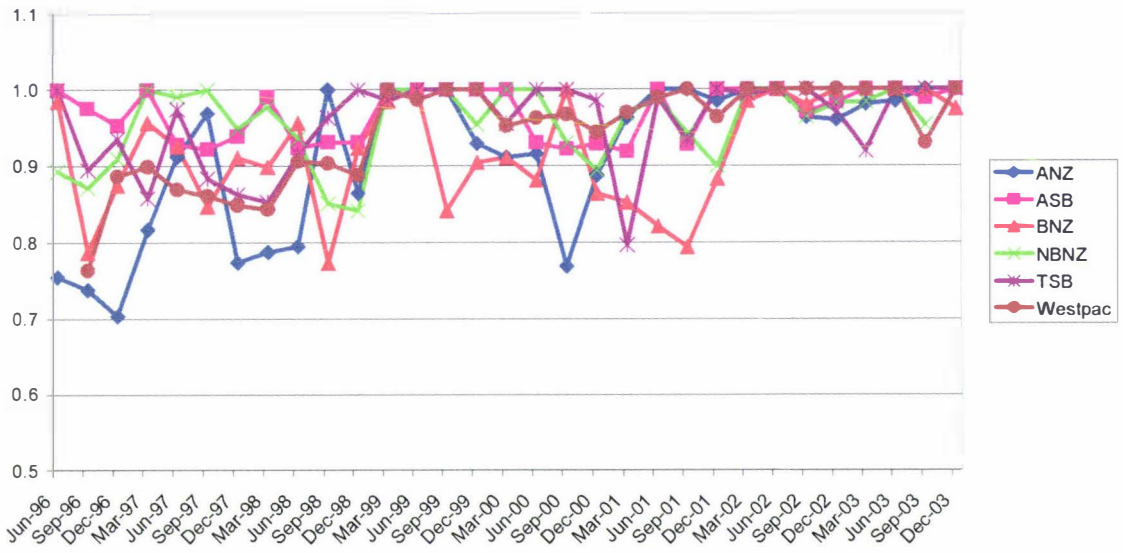
Figure 7 - Individual bank efficiency scores with inputs gross interest expense and non-interest expense (CCR model)



The relative stability of technical efficiency (as per the variable returns to scale model) through time is consistent with a gradual improvement in scale efficiency through time, as can be seen in Table 18. Figure 2 (in Chapter 2) showed that each of the banks increased significantly in size over the period of the study. Can the improvements in scale efficiency be construed as a consequence of the banks having increased their assets, with the banks having been expanding their assets to achieve economies of scale, which would be consistent with the story told by bank managements? To gain a better understanding of potential scale effects, a review has been made of the returns to scale status (as reported by the variable returns to scale models); results for this are reported in Table 19.[156] These data suggest that the banks are, in most cases, likely to be operating at increasing returns to scale.

[156] The numbers reported are for the total of efficient and projected returns to scale estimates, noting that returns to scale status, when using DEA, is strictly only defined for firms that are on the efficient frontier. Such reporting is included in the standard outputs from the software, DEA-Solver, used for this research. See footnote 90 on page 58.

Figure 8 - Individual bank efficiency scores with inputs gross interest expense and non-interest expense (BCC model)



These results are a little surprising. Banks with balance sheets of different sizes are showing similar trends in terms of economies of scale, which makes it difficult to assess what the efficient scale size for New Zealand banks might be; if they were all examined together. TSB is the smallest of the banks, and yet it has a relatively high incidence of decreasing returns to scale. These instances were all at the end of the period of the study, however, when the bank was at its largest (although still less than a tenth of the size of any of the other banks in the study, with assets of $2.03 billion as at 31 December 2003. By contrast, the ASB, with assets of $30.4 billion as at 31 December 2003, showed increasing returns to scale in four out of the last six periods in the study). The NBNZ, which was the largest of the banks towards the end of the period of the study, showed as operating at constant returns to scale, while also showing the lowest average level of scale efficiency, with that scale inefficiency concentrated during the early part of the period when, as Figure 2 shows, the bank was the fourth largest of those in the study. Is it reasonable to conclude that these differences can all be accounted for by differences in technology between the banks?[157]

[157] If banks used different technologies, the effects of scale on efficiency could become evident at different sizes.

Table 19: Returns to scale status – model studying individual banks, gross interest expense as an input (as reported by the BCC models).

	Number of increasing returns to scale	Number of constant returns to scale	Number of decreasing returns to scale
ANZ	17	12	1
ASB	10	21	0
BNZ	7	17	7
NBNZ	20	10	0
TSB	8	18	5
Westpac	10	17	3
Total	84	78	21

It would probably be reasonable on an a priori basis to accept the evidence pointing to the existence of scale economies for New Zealand banks, with banks becoming more efficient as they have grown larger. It is necessary, however, to be mindful of a more general problem that can arise with variable returns to scale models, discussed in section 3.4.1: variable returns to scale models envelope the data more tightly than do constant returns to scale models, and this effect can contribute to spurious reporting of scale inefficiencies.

Even if the scale efficiencies existed, however, there is an alternative explanation. The apparent increase in efficiency might be attributable to decreases in the general level of interest rates. The effect can be explained as follows, based on the principle that DEA measures efficiency as a ratio between inputs and outputs. Suppose as a simplifying assumption that net interest income is constant over time, and that a comparison is made between two separate time periods, one of which is characterised by high interest rates and the other by low interest rates. All other aspects of bank cost and efficiency (i.e. non-interest expense and income, quantum of business) are unchanged. Some numbers can be chosen as examples: an aggregate average cost of funds of 8% in the high interest case and a cost of funds of 4% in the low interest rate case, with a net interest income of 2% in each case. In the high interest case, interest expense of 8% is being used to generate net interest income of 2%, while in the low interest environment, interest expense of 4% is being used to generate net interest income of 2%. The ratio of the output price to input price is higher, and the bank will therefore appear to be more efficient, when interest rates are lower.

Figure 1 (in Chapter 2) showed the dramatic shifts in the general level of interest rates, particularly during the earlier part of the period studied. Prior to 1999, interest

rates in New Zealand were significantly higher than during the latter part of the period – this was also the period when much lower efficiency scores were reported by the constant returns to scale models, and when scale efficiencies appeared to be at their lowest.

It is therefore arguable that the scale efficiencies suggested for the earlier part of the period may instead be attributable to the way the variable returns to scale models envelope the data more tightly than do the constant returns to scale models. Because there was a concentration of estimated inefficiencies during the earlier part of the period, observations in this zone were more amenable to being found as efficient under the variable returns to scale model, thus leading to suggestions of scale inefficiency. The apparent improvements in efficiency may be a reflection of external factors, rather than reflecting efforts by bank management to improve efficiency.[158]

It is also relevant to go back and review the results reported in Table 17. If the difference between the results reported in Tables 16 and 17 was all attributable to scale effects, the effect of interest rate changes, in terms of the argument presented above, would appear relatively limited in terms of the empirical results reported in Table 17, and shown graphically in Figure 8. Can it be accepted that the impact of changes in the general level of interest rates would be so small?

There are two approaches to attempting to disentangle the two potential causes for the observed results. In section 5.2.2 the relationship is explored between the constant returns to scale efficiency scores and the general level of interest rates. Then, in Section 5.3 additional and varied inputs and outputs are considered, to see if the same efficiency improvements are observed through time, which might be attributed to scale effects.

5.2.2 Testing the impact of interest rates on efficiency scores

For the reasons outlined in section 4.4.2, logit regressions were used to test for the relationship between estimated efficiency scores and interest rates. The potential role

[158] An analysis for all the banks together fails to find the same evidence for the existence of scale inefficiencies, except for TSB during the earlier part of the period studied, when that bank was at its smallest.

of other explanatory variables was also investigated, namely a variable to represent time, which could reflect technical progress, and total assets, which could indicate the existence of scale economies. Note, however, that because of bank asset growth through time (as was seen in Figure 2), total assets for each bank and time are strongly correlated with each other. If regressions are run with both these explanatory variables, the variance inflation factors for these two variables exceed 10 for all but the ANZ. It was therefore necessary to avoid using these variables together in the same regression. The regressions use the (natural) log of total assets as the explanatory variable.[159] Regressions were also run using only time and (log) total assets as explanatory variables, to provide a better comparison of the explanatory powers of scale, time or interest rates.

Regression results are reported in Table 20. Note that caution has to be exercised in their interpretation as the fits are not good, and with patterns sometimes evident in the residuals. Despite these concerns, however, these results are regarded as more satisfactory than those where unadjusted efficiency scores were the response variable.[160]

Inconsistency in the results suggests that they should be reviewed one bank at a time. Thus, for the ANZ, it was found that the 90-day bill rate provided the best single explanation of the efficiency score (in terms of highest R^2 and F-statistic), with a stronger relationship for time than for total assets. For ASB, the 90-day bill rate provided the best single explanation of the efficiency score, but it is not possible to distinguish the effects of time and total assets.[161] The NBNZ also showed the 90-day bill rate providing the best single explanation of the efficiency score, but the effects of the time trend and total assets vary according to whether they are looked at individually or together with interest rates. TSB showed the 90-day bill rate as

[159] Use of log of total assets, rather than total assets, does not appear to make a difference to the regression results obtained (in terms of the R^2 and F-statistics, although F-statistics are marginally reduced). Use of the log of total assets appears to make more sense in terms of the underlying principles, in that changes in assets size would be assumed to be have more impact on scale efficiencies at smaller asset sizes.

[160] An alternative approach has been attempted to this analysis, using the natural logarithms of super-efficiency scores as the response variable, according to a procedure proposed by Lovell et al (1994) and discussed also in Lovell & Rouse (2003). This generated quite similar results, in terms of finding a strong relationship between the efficiency scores and the general level of interest rates.

[161] This may reflect particularly the strong correlation between time and total asset growth for ASB, reflecting its consistent asset growth through time.

providing the best single explanation of the efficiency score, with total assets showing as next strongest (but only in the model with two explanatory variables together).

Table 20: Regression results – logits of efficiency scores from constant returns to scale models for individual banks, gross interest expense as an input

	ANZ	ASB	BNZ	NBNZ	TSB	Westpac
A: Interest rate as sole explanatory variable						
Constant	10.653 (5.58)***	11.937 (6.46)***	6.385 (3.29)***	9.364 (5.18)***	11.28 (6.29)***	9.541 (4.08)***
Interest rate	-1.1038 (-3.88)***	-1.1916 (-4.30)***	-0.5686 (-1.96)*	-1.0028 (-3.73)***	-1.1525 (-4.29)***	-.9831 (-2.75)**
R^2	35.0%	39.0%	11.7%	33.2%	38.8%	21.3%
F-statistic	15.09***	18.52***	3.83*	13.9***	18.41***	7.57**
B: Interest rate and time trend as explanatory variables						
Constant	6.209 (1.88)*	10.365 (3.09)***	1.431 (0.43)	5.680 (1.79)*	11.876 (3.63)***	1.758 (0.48)
Interest rate	-.6850 (-1.81)*	-1.0423 (-2.70)**	-0.0976 (-0.25)	-0.6556 (-1.81)*	-1.2091 (-3.22)***	-0.2532 (-0.59)
Time	0.11019 (1.62)	0.03757 (0.56)	0.11847 (1.78)*	0.09135 (1.41)	-0.01424 (-0.22)	0.18924 (2.65)**
R^2	40.8%	39.7%	20.6%	37.7%	38.9%	37.5%
F-statistic	9.31***	9.20***	3.64*	8.18***	8.93***	8.09***
C: Interest rate and total assets as explanatory variables						
Constant	-33.56 (-0.62)	1.68 (0.09)	-23.29 (-0.63)	-20.24 (-0.76)	13.82 (0.93)	-86.53 (-2.05)*
Interest rate	-0.8685 (-2.14)**	-1.0424 (-2.70)**	-0.3511 (-0.88)	-0.6140 (-1.40)	-1.2028 (-3.00)***	-0.4959 (-1.25)
Log total assets	4.214 (0.82)	0.955 (0.56)	2.730 (0.80)	2.640 (1.12)	-0.312 (-.0.17)	8.936 (2.28)**
R^2	36.6%	39.7%	13.6%	36.1%	38.9%	34.0%
F-statistic	7.79***	9.20***	2.21	7.64***	8.91***	6.95***
D: Time as sole explanatory variable						
Constant	0.4325 (0.47)	1.6204 (1.66)	0.6123 (0.70)	0.1519 (0.17)	1.7308 (1.74)*	-0.314 (-0.31)
Time	0.19417 (3.76)***	0.16120 (3.02)***	0.13004 (2.73)**	0.17172 (3.48)***	0.12917 (2.38)**	0.21680 (4.03)***
R^2	33.6%	23.9%	20.4%	30.2%	16.4%	36.7%
F-statistic	14.17***	9.11***	7.45**	12.09***	5.67**	16.21***
E: Log of total assets as sole explanatory variable						
Constant	-118.44 (-3.03)***	-35.66 (-2.70)**	-46.79 (-1.81)*	-51.06 (-3.40)***	-22.343 (-2.25)**	-117.26 (-3.38)***
Log total assets	12.035 (3.12)***	4.098 (3.02)***	4.779 (1.92)*	5.254 (3.59)***	3.686 (2.63)**	11.585 (3.48)***
R^2	25.8%	23.9%	11.2%	31.5%	19.3%	30.1%
F-statistic	9.74***	9.10***	3.67*	12.88***	6.94**	12.08***

*** indicates significance at the 1% level
** indicates significance at the 5% level
* indicates significance at the 10% level
t-statistics are given in brackets beneath the relevant estimated coefficient

The results for BNZ and Westpac were a little different, in that, in both cases, time was the variable with the strongest impact. For BNZ, the next strongest impact was derived from the 90-day bill rate, whereas for Westpac, it appears that total assets

might be more important (but because of the correlation between total assets and time, it is difficult to disentangle the effects). The raw scores for pure technical efficiency were examined for Westpac (from the BCC model, as reported in Table 17), and it can be seen that there was a marked improvement in efficiency through time: the apparent relationship with total assets may thus arise only because asset growth and time are correlated with each other.

In the case of the BNZ, it can be seen that R^2 statistics are low in all the regressions, which suggests that the variability in efficiency scores is much more than can be explained by interest rates and time or asset growth. In the BNZ's case, a tendency has been noted (in section 4.2.1) for operating expenses to increase in the September quarter each year, and it is noted (from Table 16) that September quarter efficiency scores were often lower.[162] If a dummy variable is included to reflect September quarter results, R^2 and F statistics for the regressions improve substantially, which suggests that the results for the BNZ may have been distorted by random error effects, such as are not treated satisfactorily in DEA.

Overall it would appear reasonable to postulate that the general level of interest rates was inclined to have an effect on bank efficiency scores. The argument as to why this might be the case has been outlined above. The effect of bank size is less clear, although it would appear unwise on the basis of these results to rule out the possibility of efficiency improving as banks grow larger, thus indicating economies of scale. These issues are explored further in the next section.

5.3 Alternative input variables

The analysis reported in this section is structured as follows. It starts with the base model, as analysed for each bank separately, reviewed in sub-section 5.2.1, but with equity added as an input. In sub-section 5.3.2, still looking at each bank separately, the gross interest expense figures used as an input are replaced with the adjusted interest expense figure described in sub-section 4.4.3. In sub-section 5.3.3 the models

[162] This effect is perhaps more strongly evident in Table 17, where the "scale" effects have been eliminated by use of the VRS model.

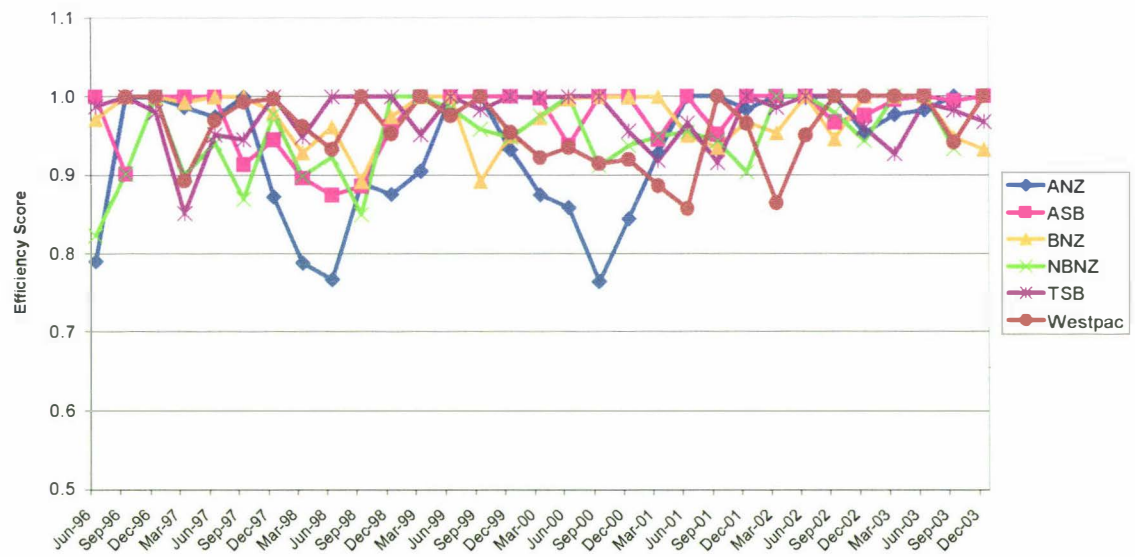
reviewed in sub-sections 5.3.1 and 5.3.2 are augmented with off-balance sheet items as an additional output, although each bank is still looked at separately.

Sub-section 5.3.4 gets to look at all the banks together, relative to a single frontier through time, using each of the models (defined in terms of their inputs and outputs) reviewed in the previous sub-sections. The results from using these models are discussed in sub-section 5.3.5.

5.3.1 Including equity as an input along with gross interest expense

Once equity is included as an additional input to the models reported in Section 5.2.1, efficiency scores change significantly. Efficiency scores for each bank, from the amended CRS model, are reported in Table 21, with the trend in efficiency scores shown in Figure 9.

Figure 9 - Individual bank efficiency scores with equity included as an input



It is noted that the efficiency scores are higher than those reported in section 5.2.1, although this may to some extent be a consequence of the increase in the total number of inputs and outputs (from four to five), reducing the degrees of freedom, and limiting the discriminatory power of the model. We also note that the trend of efficiency increasing through time observed in section 5.2.1, highlighted in Figure 7, which was suggestive of improving scale efficiency, is no longer evident.

Table 21: Efficiency scores for studies of individual banks – gross interest expense and equity as inputs

	ANZ	ASB	BNZ	NBNZ	TSB	Westpac
Jun-96	0.790146	1	0.971323	0.823098	0.987187	
Sep-96	1	0.901326	1	0.901425	1	1
Dec-96	0.999479	1	1	1	0.980372	1
Mar-97	0.986635	1	0.99273	0.899936	0.851315	0.892658
Jun-97	0.973993	1	1	0.940913	0.95148	0.969862
Sep-97	1	0.914043	1	0.869635	0.945523	0.992993
Dec-97	0.872535	0.944853	0.980258	0.976669	1	0.997222
Mar-98	0.78824	0.896346	0.928554	0.898848	0.949195	0.962046
Jun-98	0.767489	0.874771	0.961783	0.922959	1	0.932805
Sep-98	0.889567	0.886307	0.892263	0.849717	1	1
Dec-98	0.875112	0.961514	0.974335	1	1	0.952278
Mar-99	0.904614	1	1	1	0.951623	1
Jun-99	1	1	1	0.985083	1	0.975538
Sep-99	1	1	0.891965	0.958059	0.983145	1
Dec-99	0.931826	1	0.949611	0.947657	1	0.954586
Mar-00	0.874528	0.997279	0.973223	0.97516	0.999419	0.921748
Jun-00	0.858409	0.938008	0.996926	0.999606	1	0.934724
Sep-00	0.764389	1	1	0.911362	1	0.914152
Dec-00	0.844217	1	0.999358	0.937337	0.955709	0.919534
Mar-01	0.927908	0.945214	1	0.94912	0.918284	0.886393
Jun-01	1	1	0.95026	0.955062	0.966076	0.857161
Sep-01	1	0.951549	0.934965	0.94302	0.91528	1
Dec-01	0.983239	1	0.967193	0.903189	1	0.965437
Mar-02	1	1	0.953587	1	0.985601	0.864152
Jun-02	0.998455	1	1	1	1	0.950771
Sep-02	1	0.96694	0.946042	0.979055	1	1
Dec-02	0.953214	0.974772	0.999844	0.943353	0.959603	1
Mar-03	0.976565	0.995197	1	1	0.926809	1
Jun-03	0.98201	1	1	1	0.991877	1
Sep-03	1	0.993583	0.947504	0.933412	0.981456	0.941582
Dec-03		1	0.93226		0.967436	1
Average	0.931419	0.972313	0.972387	0.946789	0.973142	0.959521

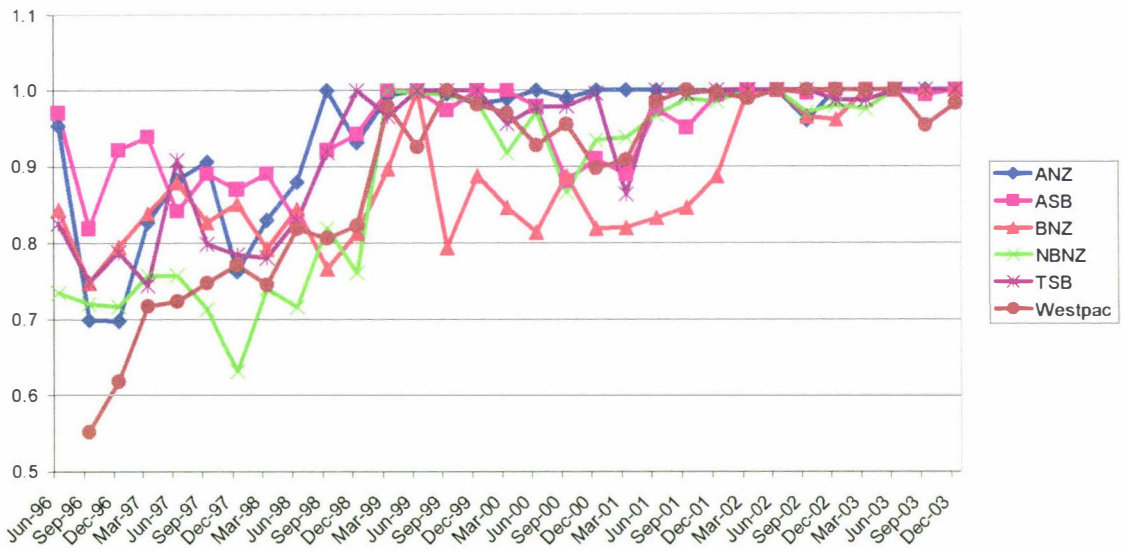
To test for scale efficiency effects, variable returns to scale models were run, and mean scale efficiencies were found to be higher for all banks than in the model with just two inputs (per section 5.2.1). This does not constitute a formal test for scale efficiencies, however, and no precedent has been found in the literature to show how such a test ought to be undertaken. It is therefore proposed that the test ought to be undertaken using the Mann-Whitney test, noting that the sets of efficiency scores for each bank will not be normally distributed, and that they will also be censored at 1 (refer to the discussion in section 3.3 above).

Using this approach, scale effects were found to be significant at the 5% level for NBNZ and TSB, and at the 1% level for Westpac. Actual scale efficiency estimates were 0.9654 for NBNZ, 0.9853 for TSB, and 0.9684 for Westpac. A closer review of

the scale efficiency estimates does not indicate any particular pattern to them, and no obvious relationship to bank asset growth through time. It is therefore problematic to try and associate the estimated scale efficiencies with changes in bank size.

To provide a more thorough comparison of the two models, the spread ratio (as per Schaffnit et al, 1997) was examined for the model without equity relative to that with equity. The results are shown in Figure 10. This shows a similar pattern to that previously observed in Figure 7. Could it be that, in the model with three inputs, gross interest expense might no longer be as effective in causing the banks to appear inefficient during the earlier part of the period when interest rates were higher?[163]

Figure 10 - Spread ratios for individual banks showing the effect of adding equity as an input



Perhaps it is a matter of identifying which input is acting as a constraint on the inefficient firms, and on seeing which inputs are being used efficiently. This can be investigated by looking at the slacks in the different efficiency models (i.e. at the inputs that are being over-utilised). Consider the example of the NBNZ. In the model with gross interest expense and non-interest expense as inputs, there are no non-radial slacks for interest expense. But once equity is introduced as an additional input

[163] In the case of Westpac, the effect may be rather more a reflection of recognising the impact of its low levels of equity during the early part of the study, made possible by its status as a branch. See also the discussion in subsection 5.3.5 below.

frequent non-radial slacks become apparent for interest expense. In other words, interest expense is no longer constraining the efficiency scores.

An alternative, simpler way of looking at this issue is to note that equity and non-interest expense will both be roughly proportionate to the size of the bank, as will the two outputs: net interest income and non-interest income. The fact that interest expense is dependent on the general level of interest rates as well as on size makes interest expense just that much less important in determining estimates of the bank's efficiency. The size effects will become relatively more important, reducing the impact of the general level of interest rates; noting that the efficiency score is a ratio of the weighted sum of outputs to the weighted sum of inputs, the score will be impacted relatively less by changes in the general level of interest rates.

5.3.2 Using an adjusted interest cost figure as an input

Use of the alternative adjusted interest expense measure also produces a model with no obvious time trend, as is evident from the results reported in Table 22 and summarised in Figure 11.

Figure 11 - Individual bank efficiency scores - Model with adjusted interest expense

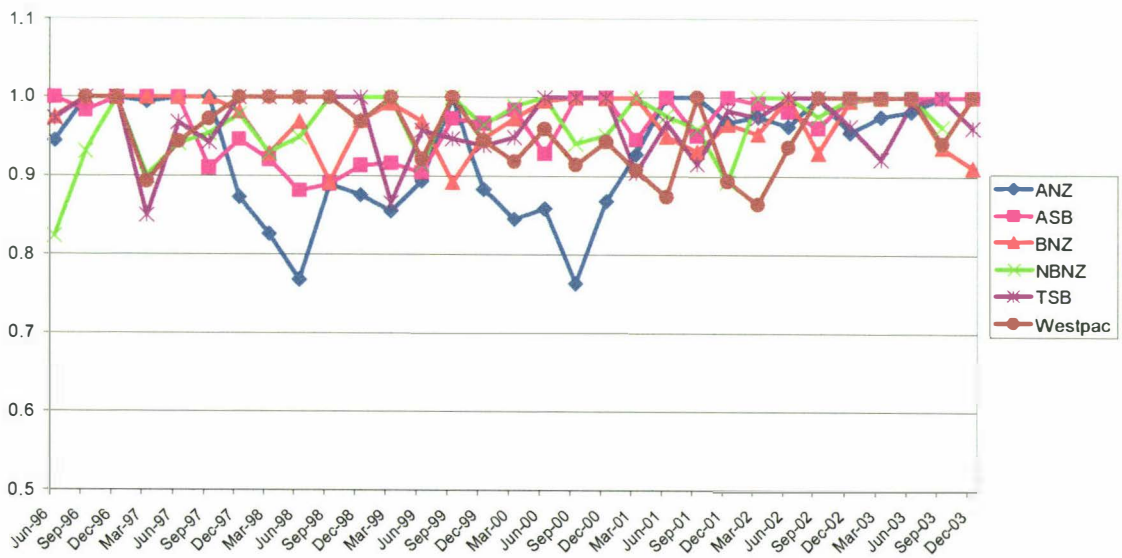


Table 22: Efficiency scores for studies of individual banks with adjusted interest cost and equity as inputs

	ANZ	ASB	BNZ	NBNZ	TSB	Westpac
Jun-96	0.944628	1	0.974716	0.823098	0.972338	
Sep-96	1	0.982447	1	0.930942	1	1
Dec-96	1	1	1	1	1	1
Mar-97	0.994092	1	1	0.899936	0.849775	0.892658
Jun-97	1	1	1	0.940913	0.967694	0.943636
Sep-97	1	0.910019	1	0.953736	0.942571	0.972214
Dec-97	0.872974	0.945823	0.981639	0.978452	1	1
Mar-98	0.82581	0.920599	0.928554	0.929737	1	1
Jun-98	0.768138	0.881596	0.969433	0.949121	1	1
Sep-98	0.889567	0.889595	0.892263	1	1	1
Dec-98	0.875666	0.913152	0.970802	1	1	0.968635
Mar-99	0.855238	0.916373	0.992273	1	0.865478	1
Jun-99	0.893529	0.90363	0.968986	0.915005	0.957979	0.921371
Sep-99	1	0.972612	0.891965	1	0.947403	1
Dec-99	0.882852	0.96663	0.94836	0.96514	0.938623	0.944553
Mar-00	0.84518	0.984032	0.973223	0.988889	0.949066	0.918221
Jun-00	0.858409	0.928236	0.995391	1	1	0.959801
Sep-00	0.763338	1	1	0.941213	1	0.914152
Dec-00	0.867846	1	0.999358	0.951819	1	0.943421
Mar-01	0.927908	0.945633	1	1	0.904518	0.907319
Jun-01	1	1	0.95026	0.976605	0.967293	0.873623
Sep-01	1	0.951266	0.931246	0.959894	0.91528	1
Dec-01	0.967574	1	0.965886	0.892523	0.983286	0.89326
Mar-02	0.975449	0.992282	0.953587	1	0.974318	0.864152
Jun-02	0.963099	0.98225	1	0.999751	1	0.936977
Sep-02	1	0.961156	0.929393	0.975884	1	1
Dec-02	0.955378	1	0.995327	0.99812	0.963516	1
Mar-03	0.975491	1	1	1	0.921465	1
Jun-03	0.98201	1	1	1	0.991877	1
Sep-03	1	1	0.936325	0.962468	0.999728	0.941582
Dec-03		1	0.910838		0.961136	1
Average	0.929473	0.966043	0.969672	0.964442	0.966882	0.959853

Tests were once again conducted for scale efficiencies, using VRS models. On this occasion, the extent of average scale inefficiency for the ANZ was greater than for the models reviewed in sub-section 5.2.1, although for all the other banks, scale efficiency effects were reduced. Scale inefficiencies were significant, however, only for the BNZ at the 5% level, and for the NBNZ at the 1% level.

It appears initially that there is relatively little difference between these models and those reviewed in the previous section (5.3.1), which were otherwise similar, but which used gross interest expense as an input.

To look for differences, an examination was made of results for the same banks, from the two different approaches alongside each other. A great degree of similarity was found between the two sets of efficiency scores. A number of observations appeared as efficient in both models, and some of the inefficient scores were identical under both models. The mean observations for each bank from the two sets of models are reported in Table 23. These results show that, in general, the efficiency scores for the models with gross interest expense as an input are marginally higher. This suggests that discriminatory power can be increased if models with adjusted interest expense are used, but the differences are very small, and not statistically significant at the 5% level (according to the Mann-Whitney test).

A valid test for a difference would be likely to entail use of a much larger sample, such as might be generated by considering all of these cases together in a single analysis, which are reported in section 5.3.4 below.

The relative similarity in the results should not be a surprise, as it was already found in section 5.3.1 that interest expense was not generally acting as a constraint in the determination of efficiency scores. The ratio between the efficiency scores generally only differs significantly from one when there was something unusual happening in respect to a particular bank's interest costs. Thus, for each of the banks, the ratio of efficiency score with gross interest expense as an input relative to that with adjusted interest expense as an input exceeded one at the point where interest rates troughed, as in the June quarter 1999. It thus appears that the analysis is identifying some of the random disturbances not accounted for by DEA.

Comparing these findings with those of section 5.3.1, it may be sufficient to just add shareholders' equity as an input to generate meaningful efficiency scores. This is because of the complexity in generating the adjusted interest expense figure and its failure to significantly sharpen the differences in efficiency scores. This would also avoid the complications (potential circularity) that arise from using an interest cost figure which is based on an average that includes the interest cost of the bank that is being studied, and which might shift over time relative to the general level of interest

rates.[164] For the next sub-section, however, where an additional output variable is added, and for the following sub-section (5.3.4), where all banks are studied together, this input will be retained, and the impact of its use explored.

Table 23: Comparison of means of models for individual banks with gross interest expense and adjusted interest expense as inputs

	Gross interest expense as input	Adjusted interest expense as input
ANZ	.9314	.9295
ASB	.9723	.9660
BNZ	.9724	.9697
NBNZ	.9468	.9644
TSB	.9731	.9669
Westpac	.9595	.9599

5.3.3 Inclusion of off-balance sheet items as an input

The results for inclusion of off-balance sheet items as an additional output variable are reported in Tables 24 (which has gross interest expense as an input) and 25 (which has adjusted interest expense as an input). The results obtained can be compared with each other, but it is also reasonable to compare the results of Tables 24 and 21 and 25 and 22, to see the effects of including off-balance sheet items as an additional output.[165]

In comparing the results reported in Tables 24 and 25, relatively little difference is evident in the average efficiency scores for each bank. This is, of course, consistent with the effect of the differing input variables explored in sub-sections 5.3.1 and 5.3.2 above, and tests confirm that the differences are not statistically significant.[166]

[164] This could be a reflection of competitive conditions, or some consistent upward or downward movements in the general level of interest rates (noting that observed, ex-post interest costs and revenues generally lag movements in the general level of interest rates, as reflected in the 90-day bill rate).

[165] This generally has the effect of increasing efficiency scores as the number of degrees of freedom is reduced.

[166] At the 5% level, according to the Mann-Whitney test.

Table 24: Efficiency scores for individual bank models with gross interest expense as input, and including off-balance sheet items as output

	ANZ	ASB	BNZ	NBNZ	TSB	Westpac
Jun-96	0.790146	1	1	1	0.987187	
Sep-96	1	0.901326	1	1	1	1
Dec-96	1	1	1	1	0.980372	1
Mar-97	0.986635	1	0.998894	0.97689	0.878298	0.946605
Jun-97	0.973993	1	1	0.98072	0.95148	0.969862
Sep-97	1	0.914043	1	0.971108	0.945523	0.992993
Dec-97	0.900732	0.944853	0.985597	1	1	0.997222
Mar-98	0.819507	0.896346	0.955852	0.934943	0.952255	0.962046
Jun-98	0.789873	0.874771	0.976205	0.960337	1	0.942223
Sep-98	0.931888	0.886307	0.936951	0.877694	1	1
Dec-98	0.882335	0.961514	0.979696	1	1	0.961739
Mar-99	0.985112	1	1	1	0.967524	1
Jun-99	1	1	1	0.985083	1	1
Sep-99	1	1	0.995381	0.958059	1	1
Dec-99	1	1	0.97781	0.947657	1	0.985389
Mar-00	0.937104	0.997279	1	0.97516	1	0.952323
Jun-00	0.984765	0.95385	0.997839	1	1	0.962083
Sep-00	0.764389	1	1	0.923803	1	0.96129
Dec-00	0.881104	1	0.999358	1	0.955709	1
Mar-01	0.9411	0.946349	1	1	0.972298	0.99512
Jun-01	1	1	0.951593	0.998083	0.982905	1
Sep-01	1	0.951549	0.934965	0.947769	0.943784	1
Dec-01	0.983239	1	0.967975	0.925761	1	0.977234
Mar-02	1	1	0.956589	1	1	0.947985
Jun-02	0.998455	1	1	1	1	0.965363
Sep-02	1	0.96694	0.946042	0.979055	1	1
Dec-02	0.953214	0.974772	0.999844	0.968559	0.959603	1
Mar-03	0.976565	0.995197	1	1	0.968088	1
Jun-03	0.98201	1	1	1	1	1
Sep-03	1	1	0.947504	0.934156	1	0.946229
Dec-03		1	0.93226		1	1
Average	0.948739	0.973068	0.981947	0.974828	0.982098	0.98219

In reviewing the extent of improvement in efficiency scores between the models reported in Tables 21 and 24, it is noted that the amount of improvement varies from bank to bank, as can be seen from the average efficiency scores shown in Table 26. Table 26 also shows the average spread ratio (as per Schaffnit et al, 1997), defined as the ratio of the efficiency score without off-balance sheet items as an output to the efficiency scores when off-balance sheet items were included as an output. Other things being equal, the relatively larger the off-balance sheet items, the greater the change in efficiency score (and the lower the spread ratio) that would be expected. Thus, for ASB, for which off-balance sheet items are relatively unimportant, hardly any increase in efficiency is reported, whereas relatively larger increases in efficiency are demonstrated for NBNZ and Westpac.

Table 25: Efficiency scores for individual bank models with adjusted interest expense as input, and including off-balance sheet items as output

	ANZ	ASB	BNZ	NBNZ	TSB	Westpac
Jun-96	0.944628	1	1	1	0.972338	
Sep-96	1	0.982447	1	1	1	1
Dec-96	1	1	1	1	1	1
Mar-97	0.994092	1	1	0.97689	0.878298	0.946605
Jun-97	1	1	1	0.98072	0.967694	0.944164
Sep-97	1	0.910019	1	1	0.944609	0.972214
Dec-97	0.90118	0.945823	0.98709	1	1	1
Mar-98	0.82582	0.920599	0.958621	0.949099	1	1
Jun-98	0.789873	0.881596	1	0.971103	1	1
Sep-98	0.931888	0.889595	0.936951	1	1	1
Dec-98	0.877711	0.92893	0.979696	1	1	0.968635
Mar-99	0.958025	0.916373	1	1	0.96839	1
Jun-99	0.903013	0.904666	1	0.915005	1	0.959053
Sep-99	1	1	0.995381	1	1	1
Dec-99	1	0.987687	0.971743	0.967405	0.991705	0.951411
Mar-00	0.937474	0.984032	1	0.988889	1	0.933092
Jun-00	0.984765	1	0.997839	1	1	0.976966
Sep-00	0.763338	1	1	0.951756	1	0.96129
Dec-00	0.885876	1	0.999358	1	1	1
Mar-01	0.9411	0.946783	1	1	0.972298	0.986513
Jun-01	1	1	0.951593	1	0.982905	1
Sep-01	1	0.951266	0.931246	0.959894	0.943784	1
Dec-01	0.967574	1	0.967975	0.913188	0.983286	0.901851
Mar-02	0.975449	0.99457	0.956589	1	0.989227	0.947985
Jun-02	0.963099	0.98225	1	0.999751	1	0.949726
Sep-02	1	0.961156	0.938854	0.975884	1	1
Dec-02	0.955378	1	0.995327	1	0.963712	1
Mar-03	0.975491	1	1	1	0.968088	1
Jun-03	0.98201	1	1	1	1	1
Sep-03	1	1	0.936325	0.962468	1	0.946229
Dec-03		1	0.912033		1	1
Average	0.948593	0.970574	0.981181	0.983735	0.98472	0.978191

Table 26: Average efficiency scores for banks studied individually before and after addition of off-balance sheet items as an output: gross interest expense as an input

	ANZ	ASB	BNZ	NBNZ	TSB	Westpac
Average *without* off-balance sheet items	0.931419	0.972313	0.972387	0.946789	0.973142	0.959521
Average *with* off-balance sheet items	0.948739	0.973068	0.981947	0.974828	0.982098	0.98219
Average spread ratio	0.981574	0.999219	0.990241	0.971374	0.990743	0.976826

The results for the models with adjusted interest expense as an input show similar effects, although the extent of efficiency improvements, as reflected in the spread

ratio, are rather less. The average efficiency scores and the average spread ratios are shown in Table 27. Once again, relatively little increase is evident for ASB, but the largest increase is now for ANZ.

Table 27: Average efficiency scores for banks studied individually before and after addition of off-balance sheet items as an output: adjusted interest expense as an input

	ANZ	ASB	BNZ	NBNZ	TSB	Westpac
Average *without* off-balance sheet items	0.929473	0.966043	0.969672	0.964442	0.966882	0.959853
Average *with* off-balance sheet items	0.948593	0.970574	0.981181	0.983735	0.98472	0.978191
Average spread ratio	0.979912	0.995416	0.988273	0.980477	0.981727	0.98113

Under both approaches, the change in average efficiency scores from the inclusion of off-balance sheet items is not particularly great. This suggests that in the New Zealand market at least, in contrast to, for example, the USA (Siems & Clark, 1997), off-balance sheet items may not be a particularly important part of bank output, at least relative to the other resources being utilised and the other outputs being generated.[167]

Having examined results for each of the banks separately through time, the research now looks at efficiency scores for all the banks together. This should assist in explaining some of the results uncovered above. Alternatively, the preceding analysis and discussion may be perceived as exploratory data analysis for the next stage of the research.

5.3.4 Analysis of all the banks together

Once all the banks are looked at together, any reported differences in efficiency scores can be construed as reflecting relative differences in banks' efficiency. Tables 28, 32, 34 and 36 report the efficiency scores generated for each bank studied together relative to a common frontier for each time period from each model, with all models constructed initially on a constant returns to scale basis. This sub-section discusses the results from each of those sets of models in sequence, looking first at a model with

[167] Note that if one looks at the ratio of mean off-balance sheet positions to mean equity, for example, even though these differ between the banks, they cannot be simply related to the changes in efficiency scores from including off-balance sheet times as an output.

gross interest expense as an input, then at a model with adjusted interest expense as an input, together with equity and non-interest expense in both cases. The third and fourth parts look at the same input sets as parts 1 and 2, but with off-balance sheet times as an additional output.

Table 28: Efficiency scores from model with all banks studied together, with equity and gross interest expense as inputs (CCR)

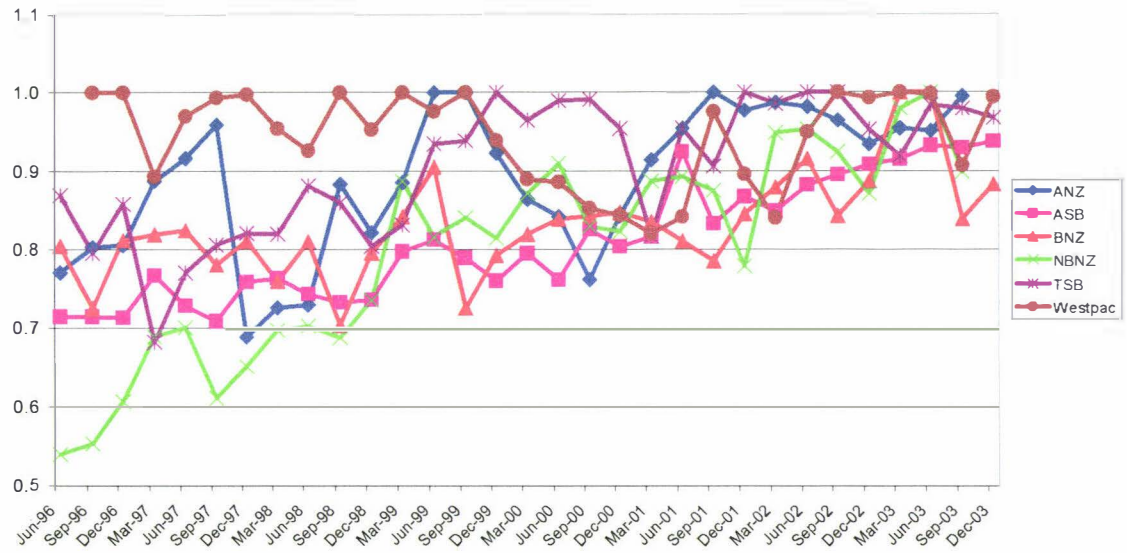
	ANZ	ASB	BNZ	NBNZ	TSB	Westpac
Jun-96	0.77048	0.714748	0.80476	0.539747	0.868833	
Sep-96	0.80269	0.714924	0.725336	0.553656	0.795626	1
Dec-96	0.805698	0.713139	0.811689	0.606798	0.858061	1
Mar-97	0.886911	0.767391	0.819296	0.689419	0.682254	0.892658
Jun-97	0.91622	0.728434	0.82463	0.70104	0.770858	0.969862
Sep-97	0.958684	0.708914	0.780573	0.611121	0.806057	0.992993
Dec-97	0.688898	0.759228	0.811257	0.651909	0.820647	0.997222
Mar-98	0.726359	0.763431	0.759941	0.697405	0.819612	0.953857
Jun-98	0.72955	0.743213	0.810135	0.702925	0.881257	0.925888
Sep-98	0.883203	0.73308	0.703644	0.688107	0.859256	1
Dec-98	0.821258	0.736441	0.796103	0.736031	0.803976	0.952278
Mar-99	0.885221	0.797502	0.841668	0.886975	0.831425	1
Jun-99	1	0.81204	0.905171	0.815943	0.934363	0.975538
Sep-99	1	0.789429	0.725959	0.840367	0.938186	1
Dec-99	0.922249	0.760263	0.792695	0.814698	1	0.938624
Mar-00	0.86354	0.794892	0.819139	0.870958	0.964236	0.889735
Jun-00	0.841715	0.761643	0.838671	0.909456	0.989401	0.885519
Sep-00	0.76144	0.825096	0.842462	0.829431	0.990716	0.85219
Dec-00	0.842919	0.803623	0.847208	0.822468	0.953934	0.843392
Mar-01	0.913749	0.815848	0.835285	0.887079	0.816745	0.820386
Jun-01	0.954061	0.924194	0.810791	0.892642	0.954455	0.841417
Sep-01	1	0.832663	0.785388	0.874748	0.905954	0.974962
Dec-01	0.976301	0.867052	0.844972	0.778931	1	0.895811
Mar-02	0.98657	0.848665	0.878759	0.948328	0.985601	0.840076
Jun-02	0.981324	0.881823	0.915419	0.952931	1	0.949175
Sep-02	0.963766	0.89457	0.842622	0.92367	1	1
Dec-02	0.933701	0.907886	0.886937	0.871105	0.952588	0.992518
Mar-03	0.953743	0.914971	1	0.979198	0.918663	1
Jun-03	0.95044	0.932174	1	1	0.983625	0.997888
Sep-03	0.994604	0.928909	0.838949	0.898672	0.979169	0.906518
Dec-03		0.937168	0.882722		0.967436	0.993344
Average	0.89051	0.810108	0.831683	0.799192	0.904288	0.942728

Thus Table 28 reports results for a model with equity, gross interest expense and non-interest expense as inputs, and with net interest income and non-interest income as outputs. Table 32 has as inputs equity, adjusted interest expense and non-interest expense. Table 34 has as inputs equity, gross interest expense and non-interest expense, while outputs now comprise net interest income, non-interest income and off-balance sheet items. Table 36 has as inputs equity, adjusted interest expense and

non-interest expense, while outputs comprise net interest income, non-interest income and off-balance sheet items.

In a graph of the results reported in Table 28 (with the graph shown as Figure 12), signs can be seen of an apparent improvement in efficiency through time. The question then arises as to whether this is a genuine improvement in efficiency, or whether it is indicative of some other effect, such as the reduction in the general level of interest rates over the period of the study.

Figure 12: Efficiency score trends for all banks together - gross interest expense as an input (CCR Model)



One way to test this is to run a variable returns to scale model and look for changes in efficiency scores. This was done, with the results reported in Table 29. From these results scale efficiencies have been estimated, with the all bank average figures reported in Table 30, along with the relative frequency of the different returns to scale status estimates, as reported by the BCC model.

Table 29: Efficiency scores from model with all banks studied together, with equity and gross interest expense as inputs (BCC)

	ANZ	ASB	BNZ	NBNZ	TSB	Westpac
Jun-96	0.771688	0.724045	0.805422	0.543441	1	
Sep-96	0.805811	0.718234	0.72596	0.557707	0.999983	1
Dec-96	0.806957	0.72083	0.812706	0.61201	0.975433	1
Mar-97	0.887432	0.775115	0.819879	0.693235	0.934593	0.898388
Jun-97	0.94534	0.732456	0.825347	0.704323	0.936115	0.971302
Sep-97	1	0.714754	0.781061	0.613244	0.934575	0.993316
Dec-97	0.690367	0.763506	0.811955	0.653186	0.961323	1
Mar-98	0.731957	0.766375	0.761167	0.700915	0.916058	1
Jun-98	0.735014	0.745725	0.811366	0.706079	0.961503	0.926164
Sep-98	0.886007	0.739445	0.704211	0.690271	0.937085	1
Dec-98	0.823407	0.739754	0.796871	0.736739	0.938286	0.954857
Mar-99	0.886413	0.798658	0.841861	0.888807	0.991177	1
Jun-99	1	0.812262	0.90752	0.817694	1	0.976027
Sep-99	1	0.789551	0.729523	0.844314	1	1
Dec-99	0.9232	0.760354	0.79505	0.81694	1	0.938792
Mar-00	0.864618	0.797023	0.821069	0.871184	0.976639	0.889789
Jun-00	0.843206	0.764392	0.838931	0.910744	1	0.886583
Sep-00	0.762664	0.826912	1	0.829986	1	0.852222
Dec-00	0.84475	0.807955	0.847411	0.823491	0.986043	0.844634
Mar-01	0.914889	0.817614	0.83553	0.888247	0.853403	0.820452
Jun-01	0.954601	0.925569	0.810962	0.893741	0.988585	0.841618
Sep-01	1	0.834167	0.7911	0.874937	0.933003	1
Dec-01	0.976385	0.869113	0.845112	0.788819	1	0.929164
Mar-02	0.986634	0.850812	0.879248	0.950228	0.993593	0.840328
Jun-02	0.982061	0.883033	0.916277	0.975654	1	0.949378
Sep-02	0.963821	0.895651	0.847388	0.93391	1	1
Dec-02	0.934398	0.908892	0.912101	0.897539	0.955447	1
Mar-03	0.955187	0.915974	1	0.989808	0.919777	1
Jun-03	0.952413	0.932998	1	1	0.988393	1
Sep-03	0.995678	0.929772	0.840678	0.921181	0.982623	0.911589
Dec-03		0.937987	0.885161		0.977028	1
Average	0.894163	0.812869	0.838738	0.804279	0.969054	0.947487

The investigation of scale efficiencies shows that, except in the case of TSB,[168] the apparent improvement in efficiency over the period of the study must be attributed to X-efficiency. This is most obvious in the case of the NBNZ, where the results from both the CCR and BCC models highlight a major improvement in efficiency after the end of 1998, an effect which might be attributed to the acquisition of Countrywide Bank in 1998.[169]

An alternative interpretation might attribute the improvement in efficiency to the bank's recovery from the adverse shock to its net interest income in 1996, which has

[168] The difference between the efficiency scores under the CCR and BCC models is significant at the 1% level, which suggests that the estimated scale inefficiency effects are significant.

[169] This would be a more significant improvement in X-efficiency associated with a merger than has usually been reported in previous research. See the discussion in Liu & Tripe (2002).

been popularly attributed to problems with the hedging of its fixed interest rate loan portfolio.[170]

Table 30: Average scale efficiency estimates and returns to scale status from model with all banks together with equity and gross interest expense as inputs

	ANZ	ASB	BNZ	NBNZ	TSB	Westpac
Average scale efficiency	0.995999	0.99641	0.9926	0.993897	0.932522	0.995095
Increasing returns to scale	16	27	19	16	23	6
Constant returns to scale	13	4	6	12	8	14
Decreasing returns to scale	1	0	6	2	0	10

One way to disentangle these effects is to look at the specific sources of inefficiency identified for the NBNZ from the DEA models, particularly during the period until the end of 1998. A review of the (radial) projections shows an over-utilisation of all inputs, although interest expense is shown as being over-utilised more than the other two inputs. Furthermore, non-radial slacks are evident for interest expense for the NBNZ for every quarter except September 1997, up to (and including) the September quarter 1998.

On an a priori basis, the results suggesting that TSB is scale inefficient might not come as a great surprise, as it is significantly smaller than the other banks in the study. This proposition is supported by a finding that scale inefficiency effects show most strongly during the earlier part of the period of the study, while the bank was smallest. It is also noted that, in the BCC model, which makes allowance for scale effects, TSB shows the highest level of pure technical efficiency (although the apparent difference in efficiency relative to Westpac is not statistically significant).[171]

These scale efficiency results for TSB are, however, not consistent with the results reported from the all-bank model used to generate the results reported in section 5.1. In that case, there was no significant scale inefficiency identified. It is also noted that the relative patterns of prevalence of increasing, constant and decreasing returns to

[170] See Tripe (1997, January). Note, however, that a rather different explanation of the problem is provided by Holmes (2003). See Tripe (2005).

[171] By contrast, differences in BCC efficiency scores relative to the other banks were statistically significant at the 1% level. Testing was undertaken using the Mann-Whitney test.

scale are quite different. In section 5.1 constant or decreasing returns to scale were reported, whereas in the models discussed in this section, increasing returns to scale are most common.

The results reported in Table 18, which looked at TSB on a stand-alone basis, with only gross interest expense and non-interest expense as inputs, also suggested some scale inefficiency, although once equity was added as an input, in terms of the results reported in Table 21, this effect was no longer evident. On the other hand, testing for factors which might have caused the variation in efficiency scores, as reported in Table 20, suggested that differences in efficiency scores were more strongly impacted by changes in the general level of interest rates, rather than by changes in the bank's total assets.

These differences in scale effects are presumed to be a consequence of the differences in the input and output sets utilised. In this case, the differences are in the input variables. Both sets of models use net interest income and non-interest income as outputs, and non-interest expense as an input. The model discussed in section 5.1 is based on use of total deposits as a further input, whereas the models reported in this section are based on inclusion of gross interest expense and equity as inputs.

An effect can also be identified arising from the way in which a variable returns to scale model envelopes the data more tightly than does a constant returns to scale model. Reviewing the slacks in the constant returns to scale model, it is found that TSB reports significant excess utilisation of interest expense from both radial and non-radial perspectives. This appears to explain much of TSB's reported inefficiency during the earlier part of the study period by the CCR model. In contrast, this same effect is not evident, and the efficiency scores are much higher, in the BCC model.

Note that this effect is also consistent with the proposition that, where gross interest expense is used as an input, differences in efficiency scores may be a consequence of differences in the general level of interest rates, rather than any genuine differences in technical efficiency. In the next model studied, where gross interest expense is replaced as an input by adjusted interest expense, there is no longer such a strong

apparent scale efficiency effect for TSB, and no strong indication of improvements in scale efficiency through time.

A further interesting point to note from Table 28 is some difference in the efficiency scores between the banks. In other words, over the period of the study, the banks were not equally efficient. Differences in the efficiency scores between banks were tested for using the Mann-Whitney test. Median efficiency scores, and the significance of any difference, in terms of the p-values applying to the differences between the medians, are reported in Table 31. These results show that TSB and Westpac are most efficient, followed by ANZ, and then ASB, BNZ and NBNZ.

Table 31: Difference in efficiency between banks – equity and gross interest expense as inputs

	ANZ	ASB	BNZ	NBNZ	TSB	Westpac
Median	.91498	.79750	.82463	.82595	.93436	.96186
ANZ		.0006**	.0060**	.0050**	.5588	.0225*
ASB			.2260	.9368	.0000**	.0000**
BNZ				.6916	.0013**	.0000**
NBNZ					.0017**	.0000**
TSB						.0571

** indicates significance at the 1% level
* indicates significance at the 5% level

The results from this analysis have already been considered alongside those reported in section 5.1 for TSB in looking for an interpretation of apparent scale effects, but it is also necessary to comment on the results for the other banks. One of the outcomes highlighted in sections 5.1.1 and 5.1.2 was the way the NBNZ's efficiency improved throughout the period of the study. The same effect has now been observed in this case. It is also noted that there is a relatively large difference between the mean and median efficiency scores for the NBNZ in Tables 28 and 31. This would appear to be a consequence of the bank's relative inefficiency in the early part of the period studied, when its efficiency scores were particularly low relative to those observed later in the period covered by the study.

Another bank which showed significant improvements in efficiency through time in sections 5.1.1 and 5.1.2 was Westpac. But this effect is not evident in Table 28 and Figure 12, with higher levels of efficiency evident at the beginning and end of the period studied, but some signs of lower efficiency during 2000 and 2001. The

difference is likely to arise from the inclusion of equity as an input in the Table 28 model. During the earlier part of the period studied, Westpac had particularly low equity in its New Zealand business, although equity increased rapidly after the December quarter 1999. Up to December 1999, the detailed results from the constant returns to scale model show that the reference sets for the inefficient Westpac cases were made up almost solely of other Westpac cases. After that time, other banks appear in Westpac's reference sets with greater frequency. This suggests that, during the earlier part of the period, Westpac may have been operating at a different part of the efficient frontier than later.[172]

The depth in which the results from Table 28 have been reported mean that it is not necessary to discuss the results from the models investigated subsequently in such depth.

The results reported in Table 32 are from a model where adjusted interest expense has replaced gross interest expense as an input. A review of the results suggests more or less immediately that, except for NBNZ, there is no longer as strong a trend of increasing efficiency through time (observed in Table 28). This might be attributed to the reduction in the general level of interest rates. This result can be confirmed by looking at the pattern of slacks. No longer is there the same concentration of excess usage of interest expense at the beginning of the period, except in the case of the NBNZ.

A further consequence of these results is the disappearance of scale inefficiency for TSB. TSB shows the lowest scale efficiency at 0.971, but the results are no longer significant at the 5% level.[173]

The differences in efficiency scores between the banks are investigated using the Mann-Whitney test. Median efficiency scores, and the significance of any difference, in terms of the p-values applying to the differences between the medians, are reported in Table 33. The ranking of the banks by relative efficiency is very similar to that

[172] The concepts underpinning this conclusion are discussed in greater depth in section 5.4.1.
[173] This was tested by a comparison of the efficiency scores from the BCC and CCR models, using the Mann-Whitney test.

found in Table 31, except that this time ANZ, TSB and Westpac can be grouped as more efficient, and ASB, BNZ and NBNZ as relatively less efficient.

Table 32: Efficiency scores from model with all banks together with equity and adjusted interest expense as inputs (CCR)

	ANZ	ASB	BNZ	NBNZ	TSB	Westpac
Jun-96	0.888802	0.77303	0.833581	0.539747	0.972281	
Sep-96	0.990715	0.752685	0.831265	0.553656	1	1
Dec-96	1	0.807508	0.957471	0.606798	1	1
Mar-97	0.988749	0.862529	0.871284	0.695979	0.75199	0.892658
Jun-97	1	0.847258	0.840773	0.703495	0.828043	0.943636
Sep-97	1	0.735696	0.82078	0.645434	0.879845	0.972214
Dec-97	0.752125	0.772272	0.845926	0.663719	0.917746	1
Mar-98	0.821472	0.780928	0.794004	0.719327	1	1
Jun-98	0.763422	0.745019	0.875084	0.724402	1	1
Sep-98	0.883203	0.73308	0.712167	0.787552	0.869923	1
Dec-98	0.854935	0.766367	0.796103	0.73745	0.811585	0.968635
Mar-99	0.825524	0.763207	0.830505	0.851282	0.744978	1
Jun-99	0.858335	0.766268	0.835701	0.759505	0.82799	0.916901
Sep-99	1	0.795114	0.725959	0.833745	0.894373	1
Dec-99	0.8741	0.747313	0.792695	0.788958	0.931755	0.920166
Mar-00	0.837562	0.802763	0.819139	0.877907	0.945528	0.881775
Jun-00	0.841715	0.776623	0.838671	0.932106	1	0.929937
Sep-00	0.763338	0.831096	0.842462	0.852868	1	0.882593
Dec-00	0.865537	0.803623	0.847208	0.83902	1	0.908894
Mar-01	0.913749	0.815848	0.835285	0.931531	0.839165	0.8707
Jun-01	0.954061	0.924194	0.814138	0.9241	0.967293	0.856667
Sep-01	1	0.832663	0.785388	0.898083	0.905954	1
Dec-01	0.945855	0.861323	0.844972	0.754449	0.982671	0.868853
Mar-02	0.951171	0.849467	0.87493	0.938652	0.974318	0.793854
Jun-02	0.942748	0.881823	0.908656	0.938183	1	0.914448
Sep-02	0.942911	0.89457	0.820492	0.91964	1	1
Dec-02	0.939946	0.907886	0.891144	0.874048	0.963516	0.995039
Mar-03	0.941145	0.914971	1	0.989119	0.92101	0.987905
Jun-03	0.920201	0.932174	1	1	0.983625	1
Sep-03	0.989442	0.928909	0.83196	0.908856	0.999728	0.872215
Dec-03		0.937168	0.876516		0.961136	0.957084
Average	0.908359	0.82398	0.844976	0.80632	0.931434	0.944472

A comparison has also been made between the efficiency scores generated by this model, with adjusted interest cost as an input, with that whose results were reported in Table 28. For each bank, the mean efficiency score from the model with adjusted interest expense as an input is slightly higher than for the model with gross interest expense as an input (the reverse of the finding in sub-section 5.3.2), although in no cases are the differences significant at the 5% level.

Table 33: Difference in efficiency between banks – equity and adjusted interest expense as inputs

	ANZ	ASB	BNZ	NBNZ	TSB	Westpac
Median	.93007	.80751	.83570	.83638	.96352	.96286
ANZ		.0001**	.0012*	.0007**	.1915	.0523
ASB			.1857	.8231	.0000**	.0000**
BNZ				.5209	.0001**	.0000**
NBNZ					.0001**	.0000**
TSB						.6175

** indicates significance at the 1% level
* indicates significance at the 5% level

Table 34 shows the results from a model which differs from that reported in Table 28 by the addition of a further output variable, off-balance sheet items.

Table 34: Efficiency scores from model with all banks together with equity and gross interest expense as inputs, off-balance sheet items among outputs (CCR)

	ANZ	ASB	BNZ	NBNZ	TSB	Westpac
Jun-96	0.77048	0.714748	0.80476	0.584104	0.868833	
Sep-96	0.80269	0.714924	0.725336	0.553722	0.795626	1
Dec-96	0.805698	0.713139	0.811689	0.606798	0.858061	1
Mar-97	0.886911	0.767391	0.819296	0.689419	0.682254	0.946605
Jun-97	0.91622	0.728434	0.82463	0.70104	0.770858	0.969862
Sep-97	0.958684	0.708914	0.780573	0.611323	0.806057	0.992993
Dec-97	0.730028	0.759228	0.811257	0.651909	0.820647	0.997222
Mar-98	0.74587	0.763431	0.759941	0.697405	0.819612	0.953857
Jun-98	0.743348	0.743213	0.810135	0.702925	0.881257	0.938346
Sep-98	0.92342	0.73308	0.703644	0.688107	0.859256	1
Dec-98	0.828727	0.736441	0.796103	0.736031	0.803976	0.961739
Mar-99	0.960124	0.797502	0.841668	0.886975	0.831425	1
Jun-99	1	0.81204	0.905171	0.815943	0.934363	1
Sep-99	1	0.789429	0.725959	0.840367	0.938186	1
Dec-99	1	0.760263	0.792695	0.814698	1	0.954248
Mar-00	0.927499	0.794892	0.819139	0.870958	0.964236	0.906552
Jun-00	0.962988	0.761643	0.838671	0.919934	0.989401	0.91472
Sep-00	0.76144	0.825096	0.842462	0.830658	0.990716	0.932059
Dec-00	0.87183	0.803623	0.847208	0.829676	0.953934	1
Mar-01	0.933292	0.815848	0.835285	0.911281	0.816745	0.989047
Jun-01	0.997339	0.924194	0.810791	0.927656	0.954455	1
Sep-01	1	0.832663	0.785388	0.874748	0.905954	0.98936
Dec-01	0.976301	0.867052	0.844972	0.780881	1	0.923613
Mar-02	0.98657	0.848665	0.878759	0.950181	0.998144	0.946409
Jun-02	0.981324	0.881823	0.915419	0.964946	1	0.965129
Sep-02	0.963766	0.89457	0.842622	0.925467	1	1
Dec-02	0.933701	0.907886	0.886937	0.887031	0.952588	0.995527
Mar-03	0.953743	0.914971	1	1	0.91968	1
Jun-03	0.952176	0.932174	1	1	0.984366	1
Sep-03	0.995246	0.928909	0.838949	0.915567	0.995387	0.927032
Dec-03		0.937168	0.882722		0.973163	0.998557
Average	0.90898	0.810108	0.831683	0.805658	0.905457	0.973429

The efficiency scores should be expected to be higher, reflecting the reduction of degrees of freedom from the inclusion of the additional output variable. By comparing the average efficiency scores, it can see that this in fact the case, although it is noted that there is no change at all in the average efficiency scores for either ASB or BNZ. A review of the slacks shows that, for these two banks, except for the two quarters where the BNZ was classed as 100% efficient, a shortfall was recorded in the production of off-balance sheet items. Off-balance sheet items were not a constraint in the determination of efficiency. For the other banks, the differences in efficiency scores were not significant at the 5% level, although the difference was significant at the 10% level for Westpac.[174]

Once again, evidence is found for TSB being scale inefficient. It has an average figure for scale inefficiency of 0.932, with the difference between the efficiency scores from the CCR and BCC models significant at the 1% level.

Tests were conducted for differences in efficiency between the banks. Median efficiency scores, and the significance of any difference, in terms of the p-values applying to the differences between the medians, are reported in Table 35. Westpac is now found to be the most efficient (reflecting its relatively greater output of off-balance sheet items), followed by ANZ and TSB, with ASB, BNZ and NBNZ less efficient.

Table 35: Difference in efficiency between banks – equity and gross interest expense as inputs, off-balance sheet items as an output

	ANZ	ASB	BNZ	NBNZ	TSB	Westpac
Median	.94294	.79750	.82463	.83017	.93436	.99118
ANZ		.0000**	.0016**	.0011**	.9712	.0025**
ASB			.2260	.9368	.0000**	.0000**
BNZ				.8230	.0013**	.0000**
NBNZ					.0035**	.0000**
TSB						.0010**

** indicates significance at the 1% level
* indicates significance at the 5% level

Table 36 shows the results from a model which differs from that reported in Model 32 by the addition of one output variable, off-balance sheet items. Efficiency scores are

[174] Westpac showed the highest average spread ratio (as per Schaffnit et al, 1997) of 1.036, which indicates the greatest change in efficiency scores from the introduction of the additional output variable.

again expected to be higher, reflecting the reduction of degrees of freedom from the inclusion of the additional output variable. By comparing the average efficiency scores, it can see that this in fact the case, although it is noted that there is no change in the average efficiency scores for either ASB or BNZ. A review of the slacks once again shows that, for these two banks, except for the two quarters where the BNZ was classed as 100% efficient, a shortfall was recorded in the production of off-balance sheet items. Off-balance sheet items were not a constraint in the determination of efficiency.

Table 36: Efficiency scores from model with all banks together with equity and adjusted interest expense as inputs, off-balance sheet items among outputs (CCR)

	ANZ	ASB	BNZ	NBNZ	TSB	Westpac
Jun-96	0.888802	0.77303	0.833581	0.584104	0.972281	
Sep-96	0.990715	0.752685	0.831265	0.553722	1	1
Dec-96	1	0.807508	0.957471	0.606798	1	1
Mar-97	0.989219	0.862529	0.871284	0.695979	0.75199	0.946605
Jun-97	1	0.847258	0.840773	0.703495	0.828043	0.944164
Sep-97	1	0.735696	0.82078	0.645434	0.879845	0.972214
Dec-97	0.764066	0.772272	0.845926	0.663719	0.917746	1
Mar-98	0.821472	0.780928	0.794004	0.719327	1	1
Jun-98	0.768864	0.745019	0.875084	0.724402	1	1
Sep-98	0.92342	0.73308	0.712167	0.787552	0.869923	1
Dec-98	0.854935	0.766367	0.796103	0.73745	0.811585	0.968635
Mar-99	0.919509	0.763207	0.830505	0.851282	0.744978	1
Jun-99	0.872229	0.766268	0.835701	0.759505	0.82799	0.955504
Sep-99	1	0.795114	0.725959	0.833745	0.896026	1
Dec-99	1	0.747313	0.792695	0.788958	0.932933	0.924063
Mar-00	0.92437	0.802763	0.819139	0.877907	0.947086	0.889982
Jun-00	0.962988	0.776623	0.838671	0.937983	1	0.949313
Sep-00	0.763338	0.831096	0.842462	0.861307	1	0.946226
Dec-00	0.879578	0.803623	0.847208	0.84359	1	1
Mar-01	0.933292	0.815848	0.835285	0.942622	0.839165	0.986513
Jun-01	0.997339	0.924194	0.814138	0.934409	0.968548	1
Sep-01	1	0.832663	0.785388	0.898356	0.905954	1
Dec-01	0.945855	0.861323	0.844972	0.755216	0.982671	0.891718
Mar-02	0.951248	0.849467	0.87493	0.945176	0.979599	0.946409
Jun-02	0.942748	0.881823	0.908656	0.944159	1	0.946516
Sep-02	0.942911	0.89457	0.820492	0.920341	1	1
Dec-02	0.939946	0.907886	0.891144	0.89279	0.963712	1
Mar-03	0.941775	0.914971	1	1	0.927423	1
Jun-03	0.922745	0.932174	1	1	0.984627	1
Sep-03	0.995609	0.928909	0.83196	0.919637	1	0.906812
Dec-03		0.937168	0.876516		0.964449	0.975982
Average	0.927899	0.82398	0.844976	0.810965	0.932148	0.971689

For the other banks, the differences in efficiency scores were not significant at the 5% level, although the difference was significant at the 10% level for Westpac.[175] Note that there appears to be a fair degree of similarity between the results reported in Tables 34 and 36. As with the model reported in Table 32, TSB shows the lowest level of scale efficiency, at 0.970, but this was not found to be significant.[176]

Tests were undertaken for differences in efficiency between the banks. Median efficiency scores, and the significance of any difference, in terms of the p-values applying to the differences between the medians, are reported in Table 37. Westpac is again the most efficient, reflecting its relatively greater output of off-balance sheet items. It is followed by ANZ and TSB,[177] with ASB, BNZ and NBNZ less efficient.

Table 37: Difference in efficiency between banks – equity and adjusted interest expense as inputs, off-balance sheet items as an output

	ANZ	ASB	BNZ	NBNZ	TSB	Westpac
Median	.94226	.80751	.83570	.83867	.96445	.99326
ANZ		.0000**	.0001**	.0001**	.5851	.0031**
ASB			.1857	.9253	.0000**	.0000**
BNZ				.5885	.0001**	.0000**
NBNZ					.0001**	.0000**
TSB						.0566

** indicates significance at the 1% level
* indicates significance at the 5% level

5.3.5 Discussion

A number of issues have surfaced in the previous sub-sections' results, which are now discussed. Issues to be considered include the existence of scale effects, the impact of changes in the general level of interest rates and the use of an adjusted interest cost variable, the causes and meaning of apparent differences in efficiency between the banks, and approaches to formulation of a best model for the analysis of bank efficiency.

Throughout sections 5.2 and 5.3 there have been indications of scale effects, particularly through time, but also for TSB, which were not evident in section 5.1.

[175] Westpac showed the highest average spread ratio (as per Schaffnit et al, 1997) of 1.031, which indicates the greatest change in efficiency scores from the introduction of the additional output variable.
[176] This was tested by looking at the difference between the efficiency scores from the CCR and BCC models, using the Mann-Whitney test.
[177] This relies on Westpac showing as more efficient than TSB at the 10% level.

One conclusion is that findings of scale effects are inclined to be dependent on the input and output sets selected. The finding of scale effects through time is only observed where gross interest expense is an input (in section 5.2). The inability to satisfactorily confirm this result using regression analysis, and its disappearance once equity was included as an additional input variable, combine to suggest that the apparent improvement in scale efficiency through time, as banks became larger, is a spurious effect. Where an improvement in efficiency through time was found in sub-section 5.3.4, this had to be attributed to improvements in X-efficiency. It is thus considered more likely that the apparent improvements in scale efficiency are a consequence of the way VRS models envelope the data more tightly.

The other suggested example of scale efficiency was in the case of TSB, although evidence for this was significant only in models that use gross interest expense as an input and not in models that used adjusted interest expense. One is inclined to the view this apparent evidence for TSB being scale inefficient as a consequence of VRS model characteristics, as discussed by Dyson et al. (2001).

The potential impact of changes in the general level of interest rates on efficiency scores has also been established. It has been found, more particularly in the models that look at data for all the banks together, that use of an adjusted interest cost figure as an alternative input can alleviate some of the adverse effects.[178] Issues that would be likely to impact such a variable would include whether or not there were significant differences in interest rates, the extent to which interest costs might constrain the estimation of efficiency scores, and the availability of a basis for adjustment. The significance of any effect might be determined by looking at the relationship between raw efficiency scores and the general level of interest rates.

The all-bank models reviewed in sub-section 5.3.4 indicated a remarkable degree of consistency in banks' efficiency rankings. This consistency in the results allows greater confidence in their reliability, consistent with the arguments proposed by Bauer et al (1998). For the CCR models, Westpac was most efficient, followed by

[178] This is even though the difference between the two sets of efficiency scores for the models reported in Tables 28 and 32 is not statistically significant: the p-value generated by the non-parametric Mann-Whitney test is 0.1717.

TSB, ANZ, BNZ and NBNZ, with ASB least efficient. For BCC models, TSB generally appeared to be more efficient than Westpac. The question thus arises as to what other factors might characterise these banks' performance, and impact on their estimated efficiency scores.

A significant contributor to TSB's superior performance is likely to be its superior generation of net interest income: its average level of net interest income for the period from the June quarter 1996 to the December quarter 2003 was 3.25% of average total assets. The next best performer was Westpac: over the period from the September quarter 1996 to the December quarter 2003 its net interest income relative to average total assets averaged 2.63%, whereas the average for the banks which dominate retail business, as a whole, was 2.46%. This contrasts with the relatively poor performance of BNZ and NBNZ in particular, at 2.35% and 2.38% respectively of average total assets for the period from the September quarter 1996 to the December quarter 2003. This is consistent with suggestions that the approach in this research is more directed at revenue efficiency, rather than cost efficiency (Chu & Lim, 1998).

Westpac's efficiency score was also enhanced by its relatively low level of equity, particularly during the earlier part of the period, and this accounts for the difference between the trend evident in the results reported in section 5.1 and those reported in sub-section 5.3.4. It could be argued that the apparent improvement in efficiency observed in Tables 13 and 14 was at least in part a reflection of a failure to take account of equity as an input. The impact of including equity as an input will be further explored in section 5.4 below.

Other effects are evident if banks' gross incomes are compared over the period of the study. For the period from the September quarter 1996 to the December quarter 2003, average gross income (relative to average total assets) was 4.28% for ANZ and 3.97% for Westpac, compared to 3.41% for NBNZ and 3.52% for ASB. Review of these revenue figures helps with understanding their significance in determining bank

efficiency in a multivariate sense, subject, of course, to the inputs and outputs used in efficiency models.[179]

It is also possible to compare the ranking of efficiency scores with a ranking by cost to income ratio. For the period from June 1996 to December 2003, the highest average cost to income ratios were for ASB at 56.5% and ANZ at 56.0%, whereas the lowest were for TSB at 52.0% and BNZ at 53.6%. Using the ratio of cost to assets, the effects are just as striking: for the period from September 1996 to December 2003, the lowest ratio was for NBNZ at 1.84%, whereas the highest ratios were for ANZ at 2.40% and Westpac at 2.15%. This evidence tends to support the proposition that simple cost ratios provide a less than complete picture of bank efficiency.

The final point to be discussed at this stage is the potential to identify a best model for analysis of bank efficiency. The range of results obtained so far, which have at times been inconsistent with each other, suggest that it may not always be easy to identify a single best set of inputs and outputs, although it can be said that inclusion of shareholders' equity seems to make a positive contribution to particular models' ability to discriminate. This is a reasonable finding. As other researchers have found (e.g. Berger & Mester, 1997, 2003), equity is an important resource used by banks, both as a source of funding, and as a foundation for risk-taking, which will allow them to take up opportunities to earn revenue.

It is likely that bank management do not look at equity in this way in reviewing the performance, including their perceptions of efficiency, for the banks that they manage. They are inclined to regard equity as expensive, and as a cost imposed on them by regulation. Because of this, they are frequently trying to reduce costs by issuance of debt-type instruments with only a bare sufficiency of equity-type characteristics to achieve regulatory capital compliance. What this research suggests is that efficient use of equity can make a rather more positive contribution to bank performance.

[179] The importance of revenue is highlighted in the way in some of the models, such as that reported in Table 22, the ANZ showed relatively higher efficiency prior to the change in accounting policy that came into effect after September 1997, and which reduced non-interest revenues.

It has also been found that, for New Zealand banks, simply adding off-balance sheet items to the output set does not necessarily have an impact, although a more meaningful distinction may be obtained using a different measure for off-balance sheet exposures. It is not clear whether off-balance sheet items are a less important part of New Zealand banks' outputs than they are for banks in other countries (e.g. Siems & Clark, 1997; Rogers, 1998) or whether alternative measurement proxies might show them as having greater impact.[180]

Other things being equal, and in terms of the argument put forward by Berger & Humphrey (1992b), use of a proxy for utilisation of funds that considers the cost of those funds should be superior to one which does not, such as total interest-bearing liabilities. If there are reasons for interest costs to be impacted by other factors, such as operation in different countries at different times, however, such an approach may not be possible. Such a situation is examined in the next section of this dissertation.

5.4 The cross-country study

This analysis is in four parts. The first part looks at whether or not it is valid to apply a common frontier to the analysis of New Zealand and Australian banks. The second part considers a model which has equity as an input, and then in the third part a model is used which does not have that input. In the fourth part, the results from the two separate models are compared.

5.4.1 Does a common frontier apply?

The high degree of similarity between the New Zealand banks and the Australian major banks (who are in most cases their owners) would seem to be supportive of arguments that there was a measure of integration between the Australian and New Zealand banking systems. It could be argued similarly that as the Australian regional banks operate in the same market, and also have branch networks, that all three groups of banks should be sufficiently similar in their operations to be studied in a

[180] Some prior research has used non-interest income as a proxy for off-balance sheet business, whereas other research has used total off-balance sheet commitments or the risk-weighted equivalent (Leong et al., 2003). The New Zealand case is perhaps unusual in having a wider range of published data to choose between.

single efficiency model relative to a common frontier. Before the analysis of banks' efficiency relative to each other proceeds, however, one should explore the proposition of whether a common frontier applies.

Very little in the way of precedent can be found for approaches to try and resolve this question.[181] One approach identified is a technique of mapping individual banks, one at a time, onto a frontier comprising a set of banks for which it can reasonably be assumed that a common frontier might apply.[182] Such relevant groups of banks might include the set of six New Zealand banks studied in sections 5.1 to 5.3 above, or a set of the major Australian banks. The effect of introducing a new bank can be examined in terms of changing the efficiency scores of banks already in the sample. If the new bank in the sample caused a change in efficiency scores for a particular bank or banks, it could be inferred that the newly introduced bank was on the same portion of the frontier as the bank(s) whose efficiency is changing.

The analysis starts with the four Australian major banks, and then examines the impact of adding Australian regional banks, one at time. Amongst other things, this allows an assessment of whether or not Suncorp-Metway properly belongs in the sample of Australian banks, an issue identified in section 4.1. The New Zealand banks are then added, one at a time, to the set of all Australian banks, to see whether a common frontier can be applied to New Zealand and Australian banks together. This initial analysis is undertaken using Model 1 (which has equity as an input).

Table 38 reports the sum of changes in efficiency for each of the major Australian banks, across the whole 8-year period of the study, as a result of the introduction of each of the Australian regional banks, one at a time and once only, to the data set of the four major Australian banks. The total impact of changes from each bank's introduction is in the second to bottom row of the table, while the right-most column of the table totals the changes for each of the major banks, and suggests which of these banks are most closely related to the regional banks in terms of position on the efficient frontier. The bottom row of the table shows the mean efficiency score for the

[181] The approach by Cook et al (1998) of looking at hierarchies and groups is not considered applicable to this problem.
[182] This approach follows a suggestion made by Alexander Karmann. A similar technique has been used by Steinmann et al (2004).

regional banks, in the model that contains only the majors and the specific regional bank.

Table 38: Impact of inclusion of Australian regional banks in efficiency comparisons against Australian major banks

	Adelaide Bank	Bank of Queensland	Bendigo Bank	Bank West	St George	Suncorp-Metway	Total
ANZ	0	0.0024	0	0	0.0039	0.0532	0.0595
CBA	0	0	0	0	0	0.1508	0.1508
NAB	0	0	0	0	0	0.2637	0.2637
Westpac	0.0110	0.0115	0.0053	0.0216	0.0172	0.0733	0.1399
Total	0.0110	0.0139	0.0053	0.0216	0.0211	0.5409	
Mean efficiency	0.9436	0.9601	0.8738	0.9396	0.8649	0.9919	

This analysis demonstrates that the regional banks have relatively little impact on the efficiency scores of the majors, with the exception of Suncorp-Metway. There are two possible interpretations for this. One is that the regional banks are generally in a different part of the efficient frontier to the majors. The alternative interpretation is that the regional banks might be significantly less efficient than the majors, being consistently off the frontier, and thus not having any impact on the position of the efficient frontier.

To explore the second of those possible interpretations, the mean efficiencies for each of the regional banks were recorded. The mean efficiency for the four major banks together is 0.9538. If the average efficiency scores for the regional banks were close to or higher than that average, it could confidently be asserted that they were not significantly less efficient than the majors, and the reason for a lack of impact on the efficiency scores for the majors was that the regionals operated in a different part of the efficient frontier. It can be concluded that Adelaide Bank, Bank of Queensland and BankWest are on a different part of the efficient frontier to where the majors are located. For Bendigo Bank and St George the situation is less clear, and one thus cannot be sure of the extent to which they are comparable with the other Australian banks.

To investigate the position of Bendigo and St George further, a DEA study was undertaken of just the Australian regional banks. Although these two banks are less

efficient on average, they make a reasonable contribution to the reference sets of the other regional banks and it is considered reasonable to study them together.

By contrast, the inclusion of Suncorp-Metway impacts rather more significantly on the efficiency scores of the major banks, and more particularly CBA and NAB (which would be likely to be the majors with the most significant insurance business). This suggests that there is a significant degree of comparability between Suncorp-Metway and the major banks.[183] It is also noted that while Suncorp-Metway impacts less strongly on the efficiency of ANZ and Westpac, the efficiency scores of these two banks are more strongly impacted by the other regional banks, suggesting that ANZ and Westpac are slightly closer, relative to the frontier, to these other regional banks.

Table 39 shows the sum of changes in efficiency for each Australian bank, across the 8-year period of the study, as a result of the introduction of each of the New Zealand banks, one at a time and once only, to the data set of all 10 Australian banks.

Table 39: Impact of inclusion of New Zealand banks in efficiency comparisons against Australian banks

	ANZ (NZ)	ASB Bank	Bank of NZ	NBNZ	TSB Bank	Westpac (NZ)	Total
Adelaide Bank	0.2487	0.4607	0.1546	0.1028	0.1642	0.3286	1.4596
Bank of Queensland	0.3877	0.0402	0.3697	0.0003	0.0162	0.7317	1.5458
BankWest	0.5149	0.3448	0.3842	0.0303	0.0110	0.6826	1.9678
Bendigo Bank	0.2936	0.0119	0.3192	0.0009	0.0001	0.5036	1.1293
St George	0.0405	0.0020	0.0147	0.0501	0.1954	0.1084	0.4111
Suncorp	0.0772	0.0314	0.0471	0	0.0404	0.1781	0.3742
ANZ (Global)	0.1438	0.0001	0.0534	0.0024	0.0048	0.1525	0.3570
CBA	0.1314	0	0.0762	0	0	0.1242	0.3318
NAB	0.0270	0	0.0046	0	0	0.0132	0.0448
Westpac (Global)	0.2245	0.0118	0.0941	0.0015	0.0034	0.1631	0.4984
Total	2.0893	0.9029	1.5178	0.1883	0.4355	2.9860	

The total impact of changes from each bank's introduction is shown in the row at the bottom of the table, while the right-most column of the table sums the changes for

[183] On the other hand, noting the high average efficiency score for Suncorp-Metway, there may be a question as to whether it properly belongs in the same data set. It seem reasonable to argue that it does, however: it shows as less that fully efficient in 3 out of 8 cases, and although its 2000 figures provide the largest single contribution to the references sets of the inefficient banks, cases for other banks also contribute significantly.

each of the Australian banks, and suggests which of these banks are most closely related to the New Zealand banks in terms of position on the efficient frontier.

The results show the strongest effect for the Australian regional banks, Adelaide Bank, Bank of Queensland, BankWest and Bendigo in particular. It appears reasonable to assume that these banks are the ones most comparable to the New Zealand banks. It is also interesting to note that the NAB is virtually unaffected by the inclusion of the New Zealand banks, and that the other major banks are affected less, suggesting that the Australian major banks may be on a different part of the frontier to the New Zealand banks.

To further explore the issue of comparability and appropriateness of a common frontier further, the reference sets for inefficient banks in both groups were examined. This was expected to show the extent to which New Zealand banks have Australian majors in their reference sets, and therefore the extent to which their performance is compared to the Australian banks, and vice versa. Table 40 reports the numbers of times efficient banks from each country appear in the references sets of the inefficient New Zealand and Australian major banks.[184]

Table 40: Frequency with which types of banks appear in reference sets

	Australian banks	New Zealand banks
Australian major banks	73	31
New Zealand banks	30	95

Although the other country's banks appear a considerable number of times in individual banks' reference sets, one cannot accept a hypothesis that there are no country-specific concentrations in the reference sets (χ^2 statistic is 48.9, which has p-value 0.000). Though the proportion of New Zealand banks in the reference sets of NBNZ and TSB, neither of which were owned by a major Australian banking group is greater than for the New Zealand banks as a whole, when these banks are removed from the analysis, the χ^2 statistic remains highly significant.

[184] Note that each inefficient bank can have up to 4 (the total number of inputs and outputs less one) banks in its reference set, which means that the number of reference set references may be substantially larger than the number of banks in the study. The inefficient New Zealand banks have more other banks in their reference sets in total as there are 6 banks, with 33 bank year observations showing as inefficient compared with just 4 Australian majors, with 29 bank year observations showing as inefficient).

The overall conclusion is that the three groups of banks are on different relative points on the efficient frontier, with the Australian majors and Suncorp-Metway generally in one group, and the New Zealand banks and the Australian regionals in another part of the frontier. This does not mean that it is inappropriate to compare the banks' efficiencies relative to each other, but rather that care may need to be exercised in interpreting any results.

5.4.2 A model with equity as an input

This section looks at the actual efficiency scores generated by the first model, and seeks to interpret them. Efficiency scores for each bank for each year are reported in Table 41, along with the averages for each bank for each year.

Table 41: Cross-country study, model 1 results (i.e. with capital as an input) – constant returns to scale

	1996	1997	1998	1999	2000	2001	2002	2003	Average
Adelaide	0.846	0.835	0.836	0.750	0.692	0.777	0.777	0.884	0.800
BoQ	0.985	0.873	0.814	0.820	0.811	0.758	0.723	0.726	0.814
BankWest	0.925	0.902	0.848	0.791	0.780	0.794	0.764	0.721	0.816
Bendigo	1.000	0.813	0.761	0.740	0.766	0.759	0.754	0.759	0.794
St George	0.950	0.860	0.787	0.782	0.773	0.792	0.790	0.875	0.826
Suncorp	0.872	0.868	0.935	0.929	1.000	0.965	1.000	1.000	0.946
ANZ	0.969	0.942	0.888	0.922	0.949	0.944	1.000	0.970	0.948
CBA	1.000	0.935	0.915	0.925	0.874	0.872	0.921	0.824	0.908
NAB	1.000	0.965	0.955	0.940	0.950	0.840	0.858	0.868	0.922
Westpac	0.909	0.898	0.907	0.876	0.906	0.926	0.815	0.877	0.889
ANZ (NZ)	1.000	0.932	0.841	0.868	0.866	0.963	1.000	0.998	0.933
ASB	0.821	0.830	0.829	0.795	0.806	0.895	0.928	1.000	0.863
BNZ	0.931	0.969	0.870	0.815	0.834	0.857	0.956	0.960	0.899
NBNZ	0.691	0.781	0.775	0.868	0.949	0.941	1.000	0.936	0.868
TSB	1.000	1.000	0.976	0.937	0.939	1.000	1.000	1.000	0.982
Westpac (NZ)	1.000	1.000	1.000	1.000	0.941	0.883	0.905	1.000	0.966
Average	0.931	0.900	0.871	0.860	0.865	0.873	0.887	0.900	

A number of points can be observed in these results. In the first place, when one examines the average figures, there is no obvious trend through time. There is a suggestion of a decrease in efficiency from 1996 to 1998, although these results are perhaps a consequence of trends amongst the Australian banks.[185] One also notes the

[185] It also raises the question as to whether there was something unusual about the results for some of the Australian banks in 1996. It is interesting to note that Sathye (2002), in looking at Australian banks for the period 1995 to 1999, generally found more positive results for productivity change. He used

significant improvement in efficiency through time for the NBNZ (and to a lesser extent ASB), consistent with results reported in section 5.1 and sub-section 5.3.4.[186]

It is also noted that TSB and Westpac (NZ) show as the most efficient among the New Zealand banks studied, consistent with the results obtained in section 5.3.4. As TSB was also the smallest of the banks in the study, this again raises questions as to whether it is likely that there were any benefits in operating at increased scale. The data used to generate the results reported in Table 40 were therefore run through a BCC model, with the results reported in Table 42.

Table 42: Cross-country study, model 1 results (i.e. with capital as an input) – variable returns to scale

	1996	1997	1998	1999	2000	2001	2002	2003	Average
Adelaide	0.848	0.841	0.850	0.750	0.694	0.790	0.778	0.906	0.807
BoQ	0.991	0.873	0.814	0.823	0.837	0.781	0.735	0.727	0.823
BankWest	0.933	0.917	0.862	0.796	0.785	0.801	0.768	0.721	0.823
Bendigo	1.000	0.829	0.764	0.743	0.767	0.761	0.755	0.763	0.798
St George	1.000	0.923	0.829	0.800	0.779	0.794	0.790	0.876	0.849
Suncorp	0.901	0.908	0.936	0.931	1.000	0.965	1.000	1.000	0.955
ANZ	1.000	1.000	0.946	0.955	0.977	0.965	1.000	1.000	0.980
CBA	1.000	0.959	0.972	1.000	0.875	0.922	0.967	0.847	0.943
NAB	1.000	0.995	1.000	0.997	1.000	0.999	1.000	1.000	0.999
Westpac	0.912	0.905	0.919	0.901	0.941	0.977	0.921	0.977	0.931
ANZ (NZ)	1.000	0.933	0.842	0.869	0.867	0.967	1.000	1.000	0.935
ASB	0.822	0.830	0.833	0.800	0.810	0.899	0.928	1.000	0.865
BNZ	0.931	0.972	0.872	0.815	0.836	0.857	0.956	0.960	0.900
NBNZ	0.694	0.784	0.784	0.878	0.953	0.942	1.000	0.998	0.879
TSB	1.000	1.000	0.976	0.983	0.992	1.000	1.000	1.000	0.994
Westpac (NZ)	1.000	1.000	1.000	1.000	0.942	0.885	0.906	1.000	0.967
Average	0.939	0.917	0.887	0.878	0.878	0.894	0.906	0.923	

This has in turn allowed a test for scale efficiency, with the results reported in Table 43. Contrary to the expectations of bank management, scale efficiency does not appear to be important overall, with average scale efficiency across all banks of 0.9819. Returns to scale status for each bank are reported in Table 44.[187]

interest expense as an input, however, and some of the effect he found may be a consequence of a reduction in the general level of Australian interest rates over that period.

[186] The improvement in efficiency for the NBNZ in this case is less than that reported in Table 27, which reflects the use of total deposit liabilities as an input rather than interest cost. This provides further support for the argument that the NBNZ's performance during 1996 and 1997 in particular, was adversely affected by interest costs.

[187] The figures reported are for the total of efficient and projected returns to scale estimates, noting that returns to scale status, when using DEA, is strictly defined only for firms on the efficient frontier.

There is no evidence for increasing returns to scale,[188] and there is a question as to whether the major Australian banks, particularly NAB and Westpac, with their relatively lower levels of scale efficiency, particularly towards the end of the period, may be suffering from decreasing returns to scale.[189]

Table 43: Cross-country study, model 1 results (i.e. with capital as an input) – measures of scale efficiency

	1996	1997	1998	1999	2000	2001	2002	2003	Average
Adelaide	0.997	0.993	0.984	1.000	0.997	0.983	0.999	0.976	0.991
BoQ	0.995	1.000	1.000	0.997	0.969	0.970	0.984	0.998	0.989
BankWest	0.992	0.983	0.984	0.994	0.994	0.991	0.995	1.000	0.992
Bendigo	1.000	0.981	0.996	0.997	0.999	0.998	0.999	0.995	0.996
St George	0.950	0.931	0.949	0.978	0.993	0.997	1.000	1.000	0.975
Suncorp	0.968	0.956	0.998	0.997	1.000	1.000	1.000	1.000	0.990
ANZ	0.969	0.942	0.939	0.965	0.972	0.978	1.000	0.970	0.967
CBA	1.000	0.975	0.941	0.925	0.998	0.945	0.953	0.973	0.964
NAB	1.000	0.970	0.955	0.943	0.950	0.841	0.858	0.868	0.923
Westpac	0.997	0.993	0.987	0.972	0.963	0.948	0.885	0.897	0.955
ANZ (NZ)	1.000	0.999	0.998	0.999	0.999	0.997	1.000	0.998	0.999
ASB	0.999	1.000	0.996	0.993	0.996	0.995	1.000	1.000	0.997
BNZ	1.000	0.998	0.998	1.000	0.998	1.000	1.000	1.000	0.999
NBNZ	0.995	0.996	0.988	0.988	0.995	1.000	1.000	0.938	0.987
TSB	1.000	1.000	1.000	0.953	0.947	1.000	1.000	1.000	0.988
Westpac (NZ)	1.000	1.000	1.000	1.000	0.999	0.998	0.999	1.000	1.000
Average	0.991	0.982	0.982	0.981	0.986	0.978	0.979	0.976	

There are indications of some differences in efficiency between the banks.

Table 44: Cross-country study, scale effects for model 1 (with equity as an input), as reported by the BCC model

	Increasing returns to scale	Constant returns to scale	Decreasing returns to scale
Adelaide	-	6	2
BoQ	-	8	-
BankWest	-	2	6
Bendigo	-	8	-
St George	-	3	5
Suncorp	-	6	2
ANZ	-	1	7
CBA	-	1	7
NAB	-	1	7
Westpac	-	1	7
ANZ (NZ)	-	7	1
ASB	-	4	4
BNZ	-	6	2
NBNZ	-	5	3
TSB	-	8	-
Westpac (NZ)	-	7	1
Total	0	74	54

[188] This is consistent with the results found in sub-section 4.1.2.

[189] With the very small sample size, the Mann-Whitney test fails to identify a significant difference between the efficiency scores from the CCR and BCC models, at the 5% level.

In this case it is considered meaningful to test for differences in efficiency between the groups of banks. Median efficiency scores for the groups, across the whole time period, are reported in Table 45. Because the distribution of efficiency scores is censored at one, and because the distribution is not normal, testing for the significance of any apparent differences between the groups has to be undertaken using the non-parametric Mann-Whitney test (Cooper et al. 2000; Casu & Molyneux, 2003).

In the first place, a significant difference is found between the efficiency of the New Zealand banks and the Australian banks as a whole, with a p-value of 0.0006. If the New Zealand banks are compared with the Australian major banks only, the efficiency differences are not significant. There is, however, a significant difference between the efficiency scores for the Australian majors relative to the Australian regional banks, with a p-value of 0.0000.

Table 45: Cross-country study, model 1 results – summary

	Median efficiency scores
All Australian banks	0.875
Australian regional banks	0.812
Australian major banks	0.922
New Zealand banks	0.938

5.4.3 Model without equity as an input

The actual efficiency scores generated by the second model can now be examined, and an effort made to interpret these. Efficiency scores for each bank for each year are reported in Table 46, along with the averages for each bank for each year.

The efficiency scores are lower overall than those reported in Table 41, reflecting the reduced number of inputs and the consequent increase in degrees of freedom. Although there is no obvious trend through time in the average efficiency scores, the New Zealand banks as a whole do show an improvement, consistent with the results reported in Section 5.1 (and Figure 5 in particular).[190]

[190] Note, however, that individual efficiency scores will differ, even though the input and outputs sets are the same, because of the enlarged data set against which the relative efficiencies are being measured.

Table 46: Cross-country study, model 2 results (i.e. without capital as an input)

	1996	1997	1998	1999	2000	2001	2002	2003	Average
Adelaide	0.813	0.805	0.802	0.713	0.657	0.707	0.711	0.752	0.745
BoQ	0.963	0.828	0.774	0.784	0.769	0.715	0.697	0.712	0.780
BankWest	0.883	0.858	0.809	0.754	0.747	0.746	0.726	0.697	0.777
Bendigo	0.892	0.745	0.723	0.709	0.742	0.735	0.734	0.740	0.753
St George	0.930	0.860	0.787	0.782	0.773	0.789	0.788	0.875	0.823
Suncorp	0.822	0.831	0.899	0.886	1.000	0.965	0.994	1.000	0.925
ANZ	0.870	0.867	0.871	0.921	0.948	0.943	1.000	0.970	0.924
CBA	1.000	0.927	0.894	0.906	0.874	0.872	0.921	0.824	0.902
NAB	1.000	0.964	0.954	0.940	0.950	0.840	0.858	0.868	0.922
Westpac	0.909	0.894	0.900	0.874	0.905	0.923	0.800	0.874	0.885
ANZ (NZ)	0.872	0.809	0.810	0.846	0.852	0.952	0.993	0.974	0.888
ASB	0.784	0.788	0.787	0.749	0.753	0.811	0.852	0.917	0.805
BNZ	0.881	0 922	0.828	0.784	0.798	0.823	0.934	0.947	0.865
NBNZ	0.672	0.755	0.746	0.835	0.930	0.932	1.000	0.917	0.848
TSB	1.000	0.999	0.970	0.931	0.934	1.000	1.000	1.000	0.979
Westpac (NZ)	0.722	0.804	0.896	0.904	0.899	0.877	0.905	1.000	0.876
Average	0.876	0.853	0.841	0.832	0.846	0.852	0.870	0.879	

The pattern of individual bank efficiency scores is now a little different. Median scores for the groups of banks, for Model 2, across the whole time period, are reported in Table 47.[191]

Table 47: Cross-country study, model 2 results - summary

	Median efficiency scores
All Australian banks	0.859
Australian regional banks	0.783
Australian major banks	0.905
New Zealand banks	0.889

Note that there now appears to be a greater degree of difference in relative efficiency between the New Zealand and Australian major banks. When the Mann-Whitney test is used to look for differences in efficiency between the groups, it is found that the New Zealand banks as a whole are more efficient than the Australian ones (with p-value 0.0441). The difference in efficiency between the Australian majors and the Australian regionals remains highly significant (with p-value 0.0000). For the New Zealand banks and the Australian majors, the difference is not significant.

[191] The lower levels of average efficiency scores are likely to be a result of the reduction in the number of inputs and outputs, from 5 to 4, compared with model 1.

5.4.4 What do the results from these two models mean?

The only difference between the models that have generated the two previous sets of results (in sub-sections 5.4.2 and 5.4.3) has been one input – equity. It is therefore reasonable to compare the results from the two models using the technique described by Schaffnit et al (1997) as the spread ratio. This is calculated by dividing the results obtained in Table 41 by those obtained in Table 46, which did not use equity as an input. Values for the spread ratio will be greater than or equal to 1: the larger the ratio, the more impact the inclusion of equity capital has on the efficiency score. Other things being equal banks that are more strongly capitalised will show a lower value for their spread ratio.[192] The effect of lower capital levels is most evident for Westpac (New Zealand) during the earlier part of the period, when it was making the most of its branch status and holding minimal levels of equity in New Zealand.

Results for the spread ratio, for each bank, for each year, are reported in Table 48.

Table 48: Spread ratios to show the impact of use of equity capital as an input

	1996	1997	1998	1999	2000	2001	2002	2003	Average
Adelaide	1.040	1.038	1.042	1.051	1.053	1.099	1.093	1.177	1.074
BoQ	1.024	1.055	1.051	1.046	1.055	1.061	1.037	1.019	1.043
BankWest	1.048	1.051	1.049	1.050	1.045	1.064	1.054	1.035	1.049
Bendigo	1.121	1.092	1.053	1.044	1.032	1.033	1.027	1.026	1.053
St George	1.021	1.000	1.000	1.000	1.000	1.003	1.002	1.001	1.003
Suncorp	1.061	1.045	1.039	1.049	1.000	1.000	1.006	1.000	1.025
ANZ	1.114	1.086	1.020	1.002	1.001	1.001	1.000	1.000	1.028
CBA	1.000	1.009	1.023	1.021	1.000	1.000	1.000	1.000	1.007
NAB	1.000	1.001	1.001	1.000	1.000	1.000	1.000	1.000	1.000
Westpac	1.000	1.004	1.008	1.002	1.002	1.003	1.018	1.003	1.005
ANZ (NZ)	1.147	1.152	1.039	1.027	1.016	1.012	1.007	1.025	1.053
ASB	1.048	1.052	1.053	1.061	1.070	1.104	1.090	1.090	1.071
BNZ	1.057	1.051	1.051	1.040	1.045	1.042	1.024	1.013	1.040
NBNZ	1.028	1.035	1.038	1.039	1.021	1.010	1.000	1.021	1.024
TSB	1.000	1.001	1.006	1.007	1.006	1.000	1.000	1.000	1.002
Westpac (NZ)	1.384	1.243	1.116	1.107	1.047	1.007	1.000	1.000	1.113
Average	1.068	1.057	1.037	1.034	1.025	1.027	1.022	1.026	

These results show that the Australian major banks are more highly capitalised than New Zealand banks, and certainly more highly capitalised than those New Zealand banks owned by the Australian majors. The question then arises as to whether the New Zealand banks are holding less capital than they might otherwise need were they

[192] Note that this is a straight capitalisation ratio, not adjusted for risk, or any other factors, such as significant holdings of goodwill (which has forced St George, for example, to hold a relatively higher level of equity).

not owned by their Australian parents, and thus able to enjoy the benefits of their parent bank reputation and credit rating. This could also provide an explanation for the differences in returns on equity highlighted in Figure 4 (in Chapter 2).

This explanation is best examined using models like models 1 and 2, but with the data sets comprising only the Australian major banks and their New Zealand operations. Once the data sets are modified, the Mann-Whitney tests can be run, comparing only the four New Zealand banks owned by the Australian majors with their parent banks. Median scores are reported in Table 49.

Table 49: Median efficiency scores for Australian majors and their New Zealand operations

	Median score from Model 1	Median score from Model 2
Australian major banks	.9253	.9080
New Zealand banks owned by Australian majors	.9296	.8856

It can be seen that there is no significant difference between the efficiency scores for banks in the two countries in Model 1, where allowance is made for use of equity capital.[193] By contrast, in Model 2, where the effect of capital is ignored, efficiency scores for the New Zealand banks are lower, with the difference significant at the 5% level (p-value is 0.0177). It can be concluded that the New Zealand operations of Australian banks are gaining the benefit of the capital levels held by their Australian parent banks.

This and other issues are explored in the next and final chapter of this dissertation.

[193] The p-value applying to the Mann-Whitney test is 0.9301.

6. Summary and conclusion

6.1 A review of the research

The focus of the study was on financial institution efficiency, looking at New Zealand banks. Substantial amounts of research have been published on financial institution efficiency in recent years, and a major part of this dissertation entailed reviewing that research and identifying a range of issues that would have to be dealt with as part of this. Particular features of the previous research which required more serious attention included the problems of working with small cross-sectional samples and an attempt to solve this by analysis of panel data as single data sets, the difficulties in identifying and selecting suitable input and output sets, and difficulties in undertaking cross-border studies. Some of the approaches followed in this research, such as the prevalent use of panel data, differ from those commonly followed in previous research, but it is believed that they are appropriately justified in terms of previous research.

This dissertation began with a review of the New Zealand banking system prior to the deregulation of the 1980s, and went on to outline some of the events that have occurred subsequently in turning the New Zealand financial system from what it was and how it performed in the early 1980s to what it has become in the 21st century. Over that time there has been significant change to the participants in the financial system, to the activities that they undertake, and to the regulatory structure within which they operate. One of the major recent changes to the regulatory structure has entailed adoption of a regime based on public disclosure of information, and it is the information disclosed under this regime that has provided the data to underpin this research. This is the first dissertation to have been able to make use of that data set, but as that data set increases in size, it is providing scope for further research opportunities.

In looking at the New Zealand banking system, however, this dissertation has not provided a detailed study of every bank that has operated in New Zealand over the primary period at which the study has been directed (1996-2003). The research has

focused on a core group of six banks: ANZ, ASB, BNZ, NBNZ, TSB and Westpac. These banks were in business continuously throughout the period of the study, and they were all names which were generally familiar to the majority of New Zealand's population as banks with which they could do business. They all conducted a reasonably broad range of business, through branch networks, even though TSB's physical network was limited to Taranaki (a provincial area with a population under 100,000), and the range of business it entered into was less extensive than that of the other five banks. They thus constituted a group whose performance was expected to be able to be validly compared. The period of the study was also generally appropriate for this group of banks: it began with Westpac's acquisition of Trust Bank New Zealand, and ended with the ANZ's acquisition of the NBNZ, which cemented the Australian dominance of the New Zealand banking system.

The research itself comprised a range of research questions. It first looked at the appropriateness of the multivariate approach to the measurement of bank efficiency, comparing and contrasting the Malmquist Index and DEA analysis of panel data, and explaining the difference between the results from those approaches and use of the more common cost to income ratio for measurement of bank efficiency. It then went on to look at a quite specific issue which applies for the analysis of bank efficiency in different time periods or in different locations: what happens if interest cost is used as an input, and there are differences in the general level of interest rates applying to different decision-making units. In such an environment, there is a danger that differences in efficiency may only reflect differences in the general level of interest rates (or other environmental factors) applying to different firms.

From identifying a problem with one particular input variable, the research went on to look at some of the impacts of the selection of a range of different input and output variables, and identified the importance and value of including equity capital as an input. The last part of the research then set out to explore one of the issues that arises from the foreign ownership of the New Zealand banking system: are New Zealand banks more or less efficient than Australian banks, particularly as New Zealand banks appear to record rather higher levels of return on equity.[194] The conclusion was that

[194] This also relates to the tax issue discussed in sub-section 4.2.1. above.

the differences were likely to be a reflection of different levels of equity being applied. In the course of this analysis it has become clear that equity is an important component to the modelling of bank efficiency.

The research has also failed to find evidence to support some commonly accepted myths about the way the banks work and prosper, even if these myths have not been specifically debunked. Very little evidence was found for banks having got more efficient through time, apart from in those cases where banks had been particularly inefficient at the start of the period of the study. Banks may have got bigger, and their operating costs may not have increased at the same rate as their size, but that does not mean that they have got more efficient. Linked to this was the lack of any convincing evidence for the existence of economies of scale in the commonly-expected shape of increasing returns to scale. Common sense encourages one to think that these ought to exist, but in this study at least, no reliable evidence has been found to support this supposition. This undermines arguments that might otherwise be adduced in support of bank mergers, and which have been used in support of mergers in Australia and New Zealand.

A key reason why the results from this research differ from those suggested by a focus on the cost to income ratio is that the multivariate approaches allow a greater emphasis on the contribution of revenue to bank efficiency. The banks that show as more efficient generally show higher levels of revenue, which makes an interesting contrast with the prevalent attitude of banks in emphasising cost control. Further advantages from use of multivariate DEA arise from its ability to handle trade-offs between both inputs and outputs. After all, there should be no economic advantage to a bank in reducing non-interest costs if it does not also focus on interest costs, which generally comprise a greater part of New Zealand banks' costs overall.

Similar issues can arise with non-interest income, increases in which are sometimes identified as an objective by bank management. It is revenue as a whole that is important to efficient bank performance, even if there is not the same trade-off evident between the two major sources of revenue (as outputs). If the concerns raised by DeYoung & Rice (2004) could be substantiated for the New Zealand market, there may be distinct risks in emphasising non-interest income.

Another outcome of this research is an illustration of some of the potential advantages that may follow from use of DEA as a technique for measuring bank efficiency. The research has suggested that a review of patterns of slacks can inform as to the sources of inefficiency, while it can also assist in identifying factors that may act as constraints on efficiency. The research has also shown the ways in which addition of inputs, outputs and DMUs can impact on efficiency scores and their composition, and the potentially useful information that can be obtained in consequence. The composition of reference sets and identification of peers can also be important and provide useful information.

These outcomes of the research exercise can be related to the problems, aims and objectives outlined in Chapter 1 of the dissertation. Although New Zealand banks' costs have reduced over the period studied (as shown in Figure 3, in section 2.5), this has not been reflected in corresponding improvements in efficiency. All that can be said is that New Zealand banks have maintained their levels of efficiency, and that this level of efficiency has been at least comparable to that achieved by Australian banks. When one compares the New Zealand banks to the Australian regional banks, the New Zealand banks show as more efficient.

The research has also identified an issues arising from the foreign ownership of the New Zealand banking system, particularly for those banks that are Australian-owned. The Australian-owned New Zealand banks appear to make less use of capital as an input than do their parent banks. This is likely to reflect an ability to rely on their parent banks' names to conduct business in New Zealand, and the effect can be seen in the New Zealand subsidiaries having the same credit ratings as the global business of their parent banks.

As discussed in the next section, however, there are questions that this research has not been able to answer satisfactorily: the research has looked at the efficiency of the individual banks that together account for most of the assets of the New Zealand banking system, but it has not looked a the efficiency of the system as a whole.

6.2 What this research has not done

This research is not the last word on the efficiency of New Zealand banks or of the New Zealand financial system. It has not managed to look at the efficiency of New Zealand's financial system as a whole, but only at the efficiency of a small number of firms that make up a part of it, even if the part they comprise is relatively large in percentage terms. Moreover, the measure of efficiency used is only a relative measure against observed best practice: it is not known whether there is some technology available, adoption of which would allow even the best performing firms to improve. No answer has therefore been provided to the conundrum identified by Diewert & Lawrence (1999) about the lack of apparent productivity improvement in the financial services sector, although the findings obtained suggest that there may not in fact have been the productivity improvements that one might otherwise have expected to occur.

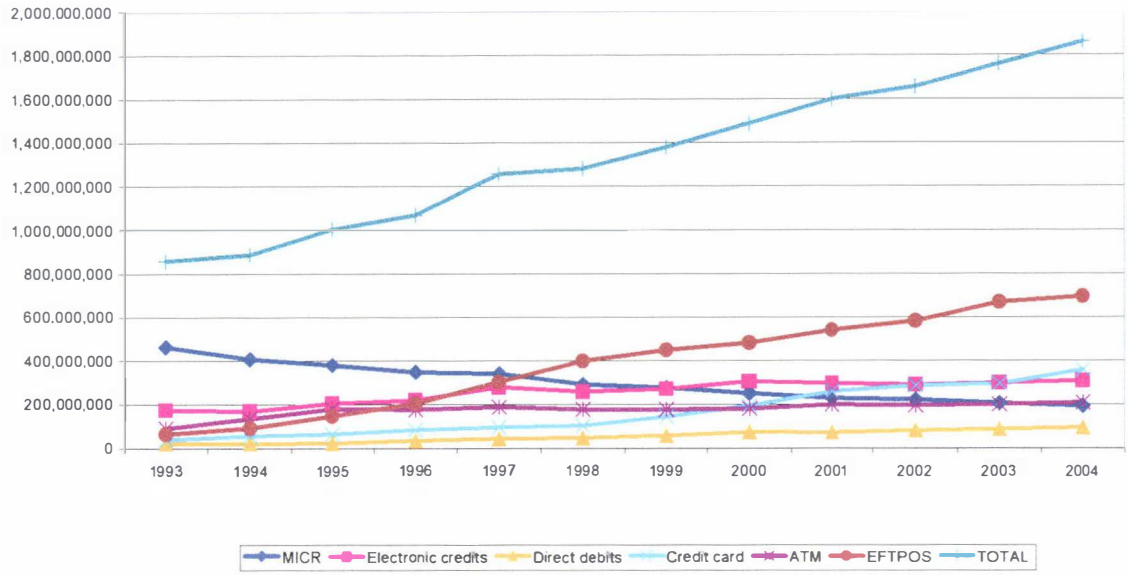
One of the ways in which such productivity improvements might have been expected to be evidenced would be through the transformation of the payments system that has occurred since the early 1990s. New Zealand used to have a payments system that was heavily based around paper, particularly cheques, but the growth in the use of EFTPOS and credit cards in the 1990s has seen dramatic changes in the patterns of use of the payments system. As is demonstrated in Figure 13,[195] the number of payment transactions undertaken in New Zealand has increased significantly, and because such a high proportion of those transactions are now undertaken using electronic methods, one would expect that the cost of those ought to have decreased, generating a welfare (economic) benefit. This has not been able to be measured, however. Measurement of these sorts of effects would require use of a production approach to modelling those financial institutions that provide such payment services, and the data at individual bank level that would make this possible are not available.

It would be desirable also to look at the efficiency of the New Zealand payments system compared to those that operate in other countries. Is New Zealand's relatively integrated electronic system such an advantage, and what is the relationship between competitive conditions and efficiency in the payments system? What are the

[195] Data for this have been obtained from the New Zealand Bankers' Association at http://www.nzba.org.nz/

complications of trying to measure these sorts of effects across international borders? This has been a topic of debate in Australia since the publication of reports by the Reserve Bank of Australia, but it is not an issue that has been addressed in New Zealand (where payment system standards have been essentially determined by arrangement between private businesses).

Figure 13: Annual volumes of transactions through the New Zealand payments system



There are other aspects of the efficiency of New Zealand's financial system which it would also have been desirable to try and measure. Does the disclosure regime provide an efficient approach to the regulation of banks, and does the OCR regime provide an efficient basis for the conduct of monetary policy. Initial research (Petro et al, 2003) suggests that the monetary policy regime is rather more effective that the regime that operated previously, but further work is warranted to clarify this conclusion.

Another aspect of the efficiency of New Zealand's financial system is in the extent to which the financial intermediation services it provides give appropriate support to the country's economic development. This might most often be conceived as being reflected in the support that is provided to small business, which is assumed to provide a key foundation for economic growth. This is an area in which almost no research has been undertaken, and yet its importance is acknowledged internationally in that we see some of the same people (such as Allen Berger) involved in researching

both financial institution efficiency and the obstacles to the effective distribution of credit to small business.[196] If it is exceptionally difficult for small businesses to access funding through the banking system, it is hard to argue that the financial system is therefore operating efficiently.

6.3 Limitations of this research

Some of the limitations of this research have been identified in the previous section where there was a review of what the dissertation did not address. However, even in the areas where some attempt has been made to cover issues, the treatment has not been as successful of effective as might have been hoped. This section seeks to identify some of these limitations, which provide a link into the future research challenges and opportunities discussed in the next section.

An obvious limitation arises from the small cross-sectional sample of New Zealand banks, which has forced the use of panel data. Although this has some precedent in previous research, and it has been affirmed as a valid approach by Tulkens and Vanden Eeckaut (1995), it raises a conundrum in interpreting efficiency in different time periods, in terms of distinguishing the effects of efficiency change and technical change. Attempts to clarify this through use of the Malmquist Index must be open to question because of the small cross-section. For all that, it is believed that the approach followed in using panel data is the best available under the circumstances.

Another limitation has been in use of logit regression to explore the impact of changing levels of interest rates on efficiency measures. Where logit regression has been used for second stage regression of efficiency scores in previous research, this has generally been applied to efficiency scores generated under the SFA approach (e.g. Mester, 1996), which will not be distributed in the same way as scores generated by DEA. A particular problem arises with DEA in that the logit of an efficiency score of 1 cannot be defined. It is likely that tobit regression, as recommended by Coelli et al (1998), would be a more satisfactory approach.

[196] See, for example, Berger & Udell (2002) and the references contained therein.

It also appears that the proxy chosen for off-balance sheet business, in terms of an untransformed total of the face value of off-balance sheet items, but not including interest rate and foreign exchange contracts, may not be optimal. This may be why the research has failed to establish the significance for off-balance sheet business found in other research (Siems & Clark, 1997; Clark & Siems, 2002). Some options for overcoming this are discussed in the next section.

Another area of limitation has been in attempting to compare the efficiency of banks in New Zealand and Australia. There is no published data which reports the financial statements of just the Australian business of the major Australian banks, and the data used for the Australian majors has therefore included their New Zealand operations. Because the New Zealand operations have comprised only a relatively small part of the Australian banks' business the distortions this might have caused would only be expected to be minor, although this can be expected to change in the future, for the ANZ at least, where, following its acquisition of the NBNZ, operations in New Zealand now comprise a much larger proportion of its overall business.

This provides us with a timely reminder that the quality of any research must ultimately be constrained by the quality of the data used to undertake it. Although the data provided by the New Zealand disclosure regime is a great resource, it is subject to limitations, and there have sometimes been suggestions that some of the reporting is not as helpful as it might be. Moreover, the data available is only financial statement data, and does not provide for any breakdown of financial magnitudes into quantities and prices, such as would be necessary to make assessments of allocative efficiency, or to follow orthodox procedures for investigation of profit efficiency (see Berger & Mester, 1997). This is also one of the reasons why this research had to use DEA.

Another aspect of limitation arising from the data is the failure of DEA, as used in this study, to account for random error. It is believed that judicious selection of cases for inclusion and checking using the super-efficiency model have allowed us to avoid inclusion of anything that would particularly distort the results obtained, but the use of

non-parametric techniques provides less confidence in this regard that might be adduced if parametric methods had been used.

There are some lesser limitations as well. No satisfactory explanation is immediately evident for the correlations between the inputs and outputs to the models used to study the ANZ and Westpac in sections 5.2.and 5.3 (as reported in sub-section 4.4.3). This also reflects the question of the appropriateness of correlation analysis as a basis for confirming input and output selections. This is a suitable subject for further research, along with the issues outlined in the next section.

6.4 Future research challenges and opportunities

Future research opportunities do not all have to be as broad-ranging as those identified in section 6.2. One outcome will be the opportunity to look at the efficiency of New Zealand financial institutions over a longer period of time, which may also allow us to observe the performance of financial institutions in economic circumstances which are less favourable than have been enjoyed over the period of this research. It would also give us the opportunity to assess the effect on the efficiency of individual institutions of the ANZ's acquisition of the NBNZ at the end of 2003, and the potential effect of the growth and development of the business undertaken by Kiwibank and Superbank (St George Bank New Zealand Ltd), both of which were only in start-up phase at the end of the period covered by this research.

It would also be desirable to investigate the impact of different input and outputs sets, and of different approaches to efficiency analysis. Some initial exploratory work is already in train to investigate the impact of customer service quality and asset growth measures on efficiency scores, taking advantage of the flexibility of DEA to deal with non-financial inputs and outputs. There is a risk otherwise that some of the results obtained in this research appear to be relatively trivial. Future research might also look at alternative ways of measuring off-balance sheet business, such as through total risk-weighted assets: some exploratory work is under way to look at the usefulness of

such a measure, which might provide a more generally valid risk-adjusted measure of a bank's output.[197]

There is also scope to try a range of different types of DEA models, such as the slacks-based and super-efficiency models (see Cooper et al, 2000). There are indications, for example, that the mix inefficiencies as measured using the slacks-based approach might highlight some of the issues that arose when off-balance sheet items were included in the all-bank models in sub-section 5.3.4. The super-efficiency model might provide a more satisfactory basis for second stage regression analysis (Lovell et al, 1994). Also, despite the limitations imposed by the relatively small cross-section and the lack of data on prices, it may be possible to attempt use of parametric approaches (the distribution free approach – DFA - in particular). There is a worthwhile corpus of literature that has used panel data for exploration of bank efficiency.

There are some other challenges as well. There is a body of research which has looked at the relationship between bank efficiency and competitive conditions, in terms of identifying the relative merits of the structure-conduct performance hypothesis and efficient structure hypothesis (e.g. Berger, 1995; Goldberg & Rai, 1996): some proper analysis of bank efficiency in New Zealand should provide a foundation for further work in this area. It might also be that there is a feedback effect from competitive conditions back to efficiency, such as is identified under the "quiet life" hypothesis (Berger & Hannan, 1998). There is also the problem of economies of scale: it seems so obvious that they ought to exist, but why is it so hard to find any actual evidence to support them.[198]

Although this research has been undertaken with and future research may follow with a New Zealand focus, one should not assume that the research should lack wider interest or application. The distinctive feature of the New Zealand market is the extent of foreign ownership, and as globalisation causes banking systems in other countries to become increasingly foreign-owned, the questions being addressed in New Zealand

[197] Relevant data is available on a quarterly basis as part of New Zealand's disclosure regime.
[198] This finding is consistent with earlier research: see, for example, Humphrey (1985).

will come to be of increasing importance elsewhere. The rationale and justification for this research is assured!

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