Using DEA in benchmarking

Australian banks are currently generating huge profits but are they sustainable? **NECMI AVKIRAN** suggests that banks will need to scrutinise the performance of their networks to ensure future profits.

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Over the last 15 years Australian banks have mostly exhausted the benefits of cost minimisation. A similar fate awaits some of the current revenue maximisation efforts such as relationship management, wealth management, and securities trading. Industry profitability is declining due to mature domestic markets and competition from overseas. Hence, there is an increasing need to scrutinise the performance of organisational units against their peers to ensure internal inefficiencies are well understood.

Traditional ratio analysis is often either simplistic by nature or valuable information is lost in aggregation. This paper outlines a benchmarking technique known as data envelopment analysis (DEA) that identifies efficient versus inefficient units, and reports the potential improvements for inefficient units by capturing the interaction between multiple inputs (resources) and outputs.

OVERVIEW OF DEA

DEA, an efficient frontier technique, has become a popular technique in bank efficiency analysis since its first application by Sherman and Gold (1985). Berger and Humphrey (1997) provide an international survey of efficient frontier analysis of financial institution performance. DEA is a linear programming technique that computes a comparative ratio of weighted multiple outputs to weighted multiple inputs for each unit. This ratio is reported as the unit's relative efficiency score summarising the overall interaction between its inputs/outputs that cannot otherwise be captured through conventional ratio analysis.

The efficiency score is usually expressed as a number between 0 and 100 percent; ties between 100 percent efficient units can be broken by the so-called super-efficiency scores that exceed 100 (Andersen and Petersen 1993). A decision-making unit (DMU) with a score less than 100 percent is deemed inefficient relative to other units in the sample. The unit of study can be a bank branch, back office, call centre, or any other organisational unit of interest to management that can give rise to a homogeneous sample.

Figure 1 provides a graphical explanation of DEA assuming output orientation where the linear program aims to maximise outputs for given levels of inputs. The efficient banks *B*, *C* and *D* define the efficient frontier. All other (inefficient) banks are then projected onto this frontier to determine their efficiency scores and the corresponding potential improvements. For example, inefficient bank *A*, when projected onto the frontier, becomes composite bank *A'*. The difference between the actual observed values for the inputs/outputs for bank *A* and projected values for the composite bank provide measures of potential improvements.

In the following numerical example, the calculation of an efficiency score

FIGURE 1 PROJECTING INEFFICIENT BANKS ONTO THE EFFICIENT FRONTIER

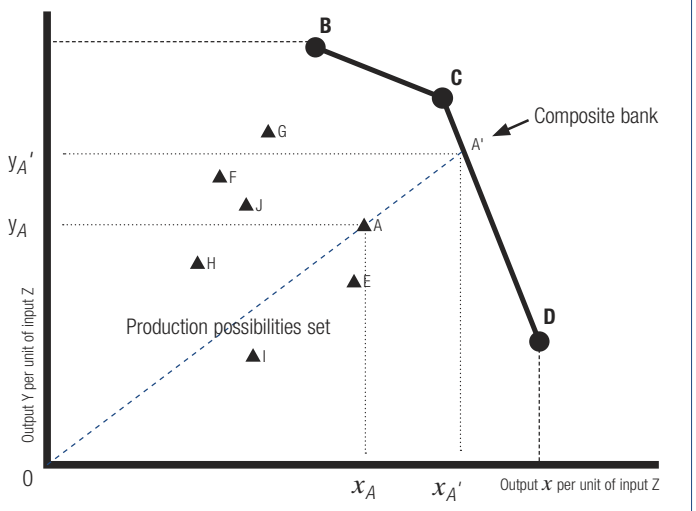
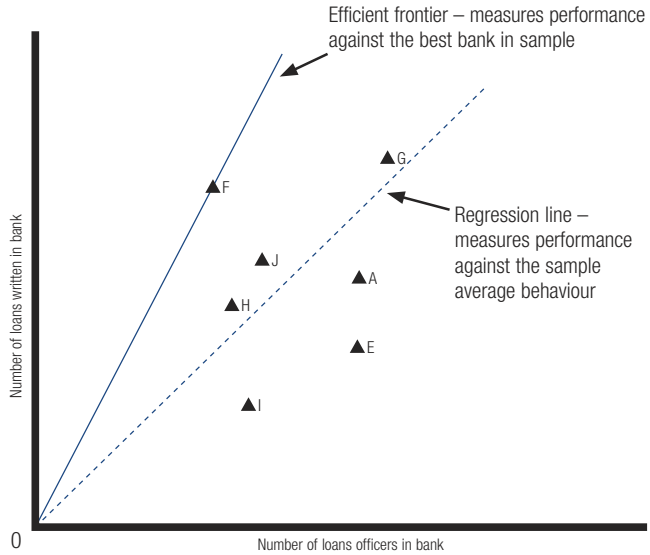


FIGURE 2 REGRESSION LINE VERSUS THE EFFICIENT FRONTIER OF DEA



and potential improvement for bank *A* in Figure 1 using the distance function below is demonstrated:

$$\frac{d_{0A}\,(x_{A'}\,y_A)}{d_{0A}\,(x_{A'},\,y_{A'})}$$

Where d_{0A} is the distance between the origin and *A*, and $d_{0A'}$ is the distance between the origin and *A'*. Assuming these values to be 8 and 10 respectively:

$^{8}/_{10} = 80\%$ is the efficiency score of unit *A* and it is known as a radial measure. Potential improvement as outputs expand can be calculated as follows:

$[(1/0.8) - 1] = 25\%$
or, $^{2}/_{8} = 25\%$

An advantage of DEA is that a unit's efficiency can be assessed based on other observed performance. As an efficient frontier technique, DEA identifies the inefficiency in a particular unit by comparing it to similar units regarded as efficient (i.e. its reference set), rather than trying to associate a unit's performance with statistical averages that may not be applicable to that unit. In the case of bank *A* in Figure 1, banks *C* and *D* on the frontier become its reference set. Furthermore, DEA reports the various potential improvements in input usage or output generation for the inefficient unit. Hence, DEA is a valuable benchmarking tool.

Figure 2 compares the more familiar regression line with the efficient frontier of DEA for a single input and single output. While regression plots a line through the sample, DEA plots an efficient frontier based on the best performing bank, i.e. bank *F,* which writes the highest number of loans per loans officer. This efficient frontier then provides a benchmark for all others in the sample.

The key disadvantage of DEA is that it assumes data to be free of measurement error and thus it is more sensitive to the presence of measurement error than parametric techniques. This can lead to statistical noise distorting efficiency scores in ways that cannot be accounted for by DEA alone. The reader is referred to Cooper, Seiford and Tone (2000) for a comprehensive technical exposition of DEA, and to Avkiran and Rowlands (forthcoming) for an approach designed to address this key disadvantage of DEA.

ILLUSTRATION OF DEA USING FOREIGN BANK DATA

In the illustrative empirical study reported below, Canadian foreign bank efficiency is analysed. Canada is a large country with a small, multicultural population dominated by an aging baby boomer group and shrinking population in remote and rural communities. The concentrated banking system that serves this population consists of 14 domestic banks (6 of which are majors), and 54 foreign banks, which include 32 foreign bank subsidiaries, 18 full service branches, and 4 lending branches. Foreign banks account for about 10% of the banking sector assets in Canada and are mainly involved in wholesale banking or niche financing.

Foreign banks, like domestic banks, are regulated under the Bank Act, which currently has a 5-year sunset provision, and are authorised to accept deposits subject to restrictions.[1] Foreign banks have been able to set up Canadian subsidiaries since 1980 and they have been allowed to establish branch banks (i.e. full service branches and lending branches) since 1999 that are allowed to carry on their commercial activities without establishing a Canadian subsidiary through incorporation. A branch can be maintained alongside an existing foreign bank subsidiary, or a subsidiary can be converted into a branch.

For the sake of expediency DEA is illustrated using a sample of 24 Canadian foreign bank subsidiaries in year 2000 (bank financial statement data are available on the website of

www.finsia.edu.au

TABLE 1 A BANK PRODUCTIVITY MODEL

Key Inputs	Key Outputs
1. Demand, notice and fixed-term deposits ($) (Deposits)	1. Loans, less allowance for impairment[3] ($) (Loans)
2. Non-interest expenses[1] ($) (NonIE)	2. Securities ($) (Sec)
3. Equity multiplier[2] (EM)	3. Non-interest income or fee income[4] ($) (NonII)

1 Salaries, pensions and other staff benefits, plus other non-interest expenses including advertising, general expenses, professional fees, and business taxes. **2** Measure of potential risk exposure, where equity multiplier is defined as average assets/average equity. **3** Loans proxy interest earned. **4** This measure is net of trading income and gains (losses) on instruments held for other than trading purposes as these items are not fee-generating activities and they are volatile.

the Office of the Superintendent of Financial Institutions). The rule of thumb for selecting a minimum sample size that will help identify inefficiencies states, 'three times the sum of the number of inputs and outputs' (see Cooper, Seiford and Tone 2000 p. 103, and Seiford and Thrall 1990 p. 29 for an explanation of this dimensionality issue). In my example, this translates into a minimum sample size of 3(3 + 3) = 18, a number that is comfortably exceeded by the actual sample size of 24.

The choice of variables is shown in Table 1. Overall, the intermediation approach to modelling bank behaviour where deposits are regarded as being converted into loans is followed. In this asset approach, the funds raised and the expenses incurred in the intermediation process are normally treated as inputs, whereas the funds loaned and income generated are regarded as outputs. According to Sealey and Lindley (1977), who are often credited with introducing the intermediation approach, designating only earning assets as outputs is consistent with rational profit maximising behaviour. Hence, the objective of banks is considered to be implementing this transfer process efficiently where outputs are maximised and/or inputs minimised.

Output orientation is the preferred approach here based on the argument that foreign banks would be more interested in maximising their outputs than minimising their inputs, which are already small compared to indigenous banks with extensive branch networks. Another argument in favour of output orientation is the nature of foreign bank business where the inputs would be mostly predetermined by the investment decision made by the parent bank, thus giving little control to the local managers of foreign banks. However, in DEA, the manager is free to select input orientation or non-oriented models as well.

Table 2 shows banks ranked in descending order as per DEA efficiency scores using the Slacks-Based Model (SBM) and generating super-efficiency scores under output maximisation and variable returns to scale assumptions (Tone 2002). The first 12 banks are efficient and the super-efficiency scores allows further ranking among them. The ranking tie between Tokai Bank and the State Bank of India can be broken by taking into account the number of times each bank has been emulated, i.e. frequency by which each bank appears in reference sets of inefficient banks (State Bank of India has a frequency of 9 against 1 for Tokai Bank).

For brevity, measurement of potential improvements through Bank of China only is demonstrated. Table 3 shows that the largest potential improvements for this bank are in raising securities and non-interest income when compared to the efficient banks in the sample. Those banks that Bank of China should emulate closely in lifting its performance are indicated in its reference set. Remembering the output orientation of my example, the small potential improvement seen in input EM suggests a slack (an over-utilised input or non-radial inefficiency). That is, while the securities and non-interest income are maximised, risk exposure (as captured by EM) can be simultaneously reduced.

AN APPLICATION CHECKLIST

Finally, an application checklist is presented for the benefit of those who are keen to implement DEA (see Avkiran 2006, p. 345–346, as well as Avkiran 1999):

1. Define the decision-making unit to be studied. How many of these units are there?
2. Identify the business drivers (outputs) critical to success of the decision-making unit.
3. Identify the key resources (inputs) that support the key business drivers. Here, a process analysis can provide direction.
4. Are data on the key outputs/inputs collected in a regular and consistent manner?
5. Is there a particular angle from which you would like to analyse the units' efficiency? For example, service volume, service quality, overall efficiency, and so on.
6. Are you interested in output maximisation or input minimisation as the main objective? Or do you prefer to focus on both simultaneously?
7. Is there any evidence of variable returns to scale in the units to be analysed?
8. At this point, run the DEA calculations and determine the units reported as inefficient.
9. Are the inefficient units consistently inefficient over time?
10. Are inefficient units measured as efficient when analysed under different methods? If so, determine why. For example, see whether environmental factors have been adequately considered.
11. Identify the best practice unit in the sample, i.e. the global leader.
12. Identify the potential improvements for the inefficient units, as well as their corresponding reference sets.
13. Are there constraints to implementation of the potential improvements? To answer this, revisit the outputs and inputs studied.

TABLE 2 FOREIGN BANK SUBSIDIARIES IN CANADA RANKED ON EFFICIENCY SCORES, YEAR 2000

Rank	Bank	Score %
1	HSBC	231
2	Citibank	147
3	Sanwa Bank	139
4	UBS Bank	135
5	Deutsche Bank	134
6	Bank of Tokyo-Mitsubishi	123
7	Bank One Canada	117
8	Société Générale	110
9	JPMorgan Bank	109
10	Bank of America	108
11	Tokai Bank	100
11	State Bank of India	100
13	Credit Suisse First	92
14	ABN AMRO Bank	65
15	Dresdner Bank	51
16	Sakura Bank	50
17	Bank of China	49
18	National Bank of Greece	44
19	Sumitomo Bank	31
20	Intesa Bank	30
21	Bank of East Asia	29
22	Korea Exchange Bank	19
23	SottoBank	16
24	International Commercial Bank of Cathay	8

TABLE 3 POTENTIAL IMPROVEMENTS FOR BANK OF CHINA

Bank of China (Score 49%)	Observed data	Projection	Difference	% improvement
Deposits	204,728.00	204,728.00	0.00	0.00
NonIE	4,026.00	4,026.00	0.00	0.00
EM	6.93	6.87	-0.06	-0.87
Loans	186,106.00	191,325.44	5,219.44	2.80
Sec	29,500.00	72,581.76	43,081.76	146.04
NonII	3,896.00	10,420.33	6,524.33	167.46
Reference Set: Deutsche Bank; Sanwa Bank; State Bank of India				

14. Communicate the results of the first round of DEA to those mangers that will be affected by the projected changes to inputs and outputs. Invite feedback on the observed differences in the performance of different DMUs.
15. If the previous step uncovers significant variables that were omitted, a second round of DEA should be undertaken after such variables are satisfactorily incorporated into the productivity model.

CONCLUSION

In summary, DEA easily lends itself to multiple input/output analysis where targets are based on observed performances rather than theoretical performances that may not be feasible. DEA further helps the manager to identify a set of efficient units that are most comparable to the configuration of the inefficient unit. Combined with the knowledge of potential improvements from the DEA report, the manager can gain insight into the nature of inefficiencies in the unit. As such, DEA can become an indispensable component of the benchmarking toolkit.

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Notes

1. Subsidiaries are allowed to accept deposits and may enjoy Canada Deposit Insurance Corporation (CDIC) insurance. Full service branches are not allowed to accept deposits of less than CDN$150,000; the full-service branch is required to deposit in Canada minimum unencumbered assets of $5 million before starting business. Lending branches are not allowed to accept any deposits; the lending branch is required to deposit in Canada minimum unencumbered assets of $100,000 before starting business. J