

An investigation of TAFE efficiency

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NATIONAL CENTRE FOR VOCATIONAL EDUCATION RESEARCH



Australian Government
Department of Education, Employment
and Workplace Relations

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About the research



An investigation of TAFE efficiency

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The interest in efficiency comes from two angles. First, governments and systems have an interest in the overall efficiency of systems, and the relative efficiency of institutions within a system. Second, individual institutions may wish to benchmark themselves against their peers.

This paper employs a mathematical technique—Data Envelopment Analysis—to compare the efficiency of 58 TAFE (technical and further education) institutes across Australia. Efficiency is measured as the ‘ratio’ of outputs to inputs, with outputs being the combination of successful full-year training equivalents (that is, adjusted for load pass rates) for trade/technician and non-trade/technician courses, and the inputs being expenditure on salaries and related expenses, and other expenditure, excluding capital costs.

Efficiency scores, which take into account the size of the institution, are derived for each institute, and peer institutes are identified. However, there are likely to be environmental factors that impact on efficiency, and these need to be taken into account in any comparison of institutes.

The following are the main findings:

- ✧ According to the analysis, 17 institutes are efficient, relative to their peers.
- ✧ The environmental factor that most significantly affects efficiency is the degree of remoteness.
- ✧ Size matters, with efficiency being lower for very small and very large institutes. On the whole the penalty is greater for very small institutes.

While it is acknowledged that the technique has many limitations, it does allow institutes to benchmark themselves. The results should provoke questions, if not answers. In addition, the analysis should be helpful to those considering structures that impact on the size of an institute. Readers will note that, as dictated by the National Training Statistics Committee’s data protocols, institutes are not identified. This type of analysis would be rather more informative if institutes were identified, and the protocols are currently being reviewed with this in mind.

Tom Karmel
Managing Director

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Measuring efficiency

Efficiency is of considerable interest to both individual institutes and systems. Under centrally planned or funded systems, knowledge about efficiency can be used to allocate funds between institutes. Under a more market-based structure, competition will tend to drive inefficient operators out of the market. In such an environment individual institutes will be interested in benchmarking themselves against their peers before the market potentially delivers a more extreme assessment. The purpose of this study is to investigate the efficiency of individual technical and further education (TAFE) institutes and the factors that could explain variations in their efficiency.

There has been a limited number of studies conducted on the efficiency of either TAFE institutes or universities in Australia, notably Abbot and Doucouliagos (1998, 2000) on TAFE institutes, and Carrington, Coelli and Rao (2005) on universities. The Carrington et al. paper is one of the more comprehensive studies and some of our ideas for analysis come from this work, although we extend it somewhat further.

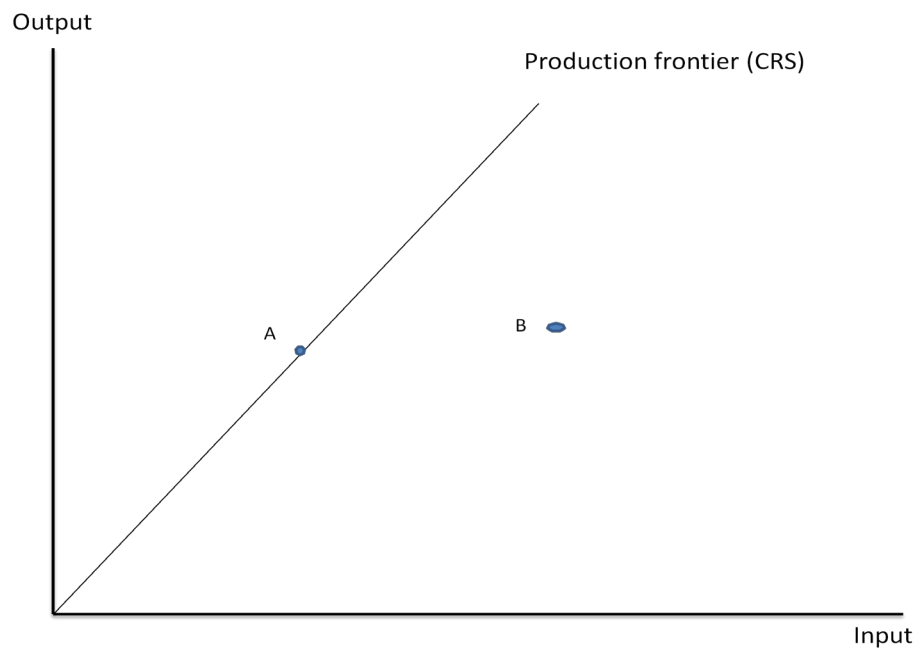
The approach used—Data Envelopment Analysis

Data Envelopment Analysis (DEA) is used to derive the relative efficiency of TAFE institutes. The idea is a simple one and is best explained by assuming a very simple world in which institutes use one input (say expenditure) to produce one output (say students).¹ Then an obvious measure of efficiency is the ratio of outputs to inputs; that is, the number of students per dollar expenditure. Graphically, this is shown in figure 1, where it can be seen that Institute A is the most efficient.

This, however, is an unrealistically simple world in which the size of the operation does not affect efficiency. If we allow size to matter, we are no longer in a world of ‘constant returns to scale’; rather, we are in a world of ‘variable returns to scale’, in which there may be economies (or diseconomies) of scale. That is, it may be cheaper per student to operate an institute with 20 000 students, say, than one with 200. The presence of fixed costs such as building infrastructure makes this very likely. However, we cannot assume that there are ever-increasing returns to scale. There may well be a point at which very large institutes become less efficient, presumably because of the complexities of running very large organisations.

¹ In the jargon of DEA an institute would be known as a ‘decision making unit’ (Cooper, Seiford & Zhu 2004)

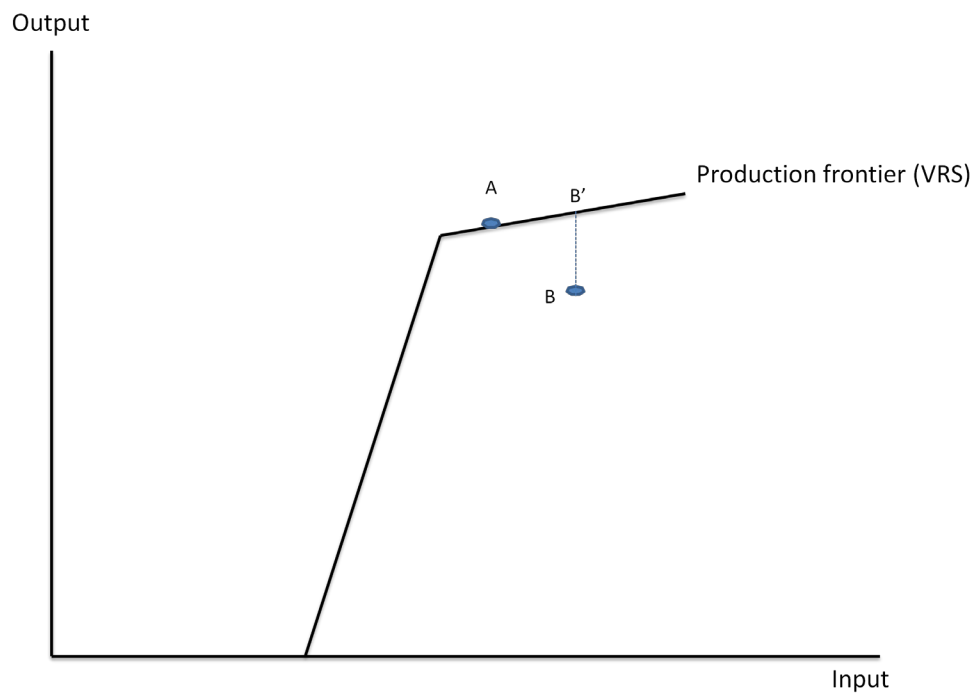
Figure 1 Efficiency under a constant return to scale assumption



Note: A is efficient, B is not.

If we assume that there are economies of scale, then we can no longer find out the most efficient institute by drawing a simple line through the origin, such that all institutes are to the right of it. We now need to draw an envelope which defines the most efficient institute for institutes of a given size; hence, the name Data Envelopment Analysis. Figure 2 illustrates the technique.

Figure 2 Efficiency under a variable returns to scale assumption



Note: B would become efficient if it moved to B'.

While this technique appears straightforward, it becomes considerably more complex if we allow for multiple outputs and multiple inputs. Such a situation is more realistic and certainly is the case for TAFE institutes. In this case the data envelope has to balance a number of outputs against a number of inputs, and the mathematics becomes quite complex (no longer can we draw a simple diagram). In practice there is a limitation that we need to impose on our analysis: the number of inputs and outputs is constrained by the number of observations that we have. Thus with 60 odd TAFE institutes we restrict the analysis to two inputs and two outputs:

- ✧ inputs: expenditures on salaries, wages and related expenses; and other expenditure (excluding capital costs)²
- ✧ outputs: full-year training equivalents,³ split into trades/technicians and non-trades/technicians, and adjusted for load pass rates.⁴

While the inputs are pretty obvious, if a little limited, the choice of outputs is intended to reflect the difference costs associated with delivering trade/technician qualifications relative to non-trade/technician qualifications.

Before we get down to the analysis there are two technical terms we need to explain. These are:

- ✧ *Technical efficiency*, which refers to how many outputs an institute produces for given inputs, relative to an efficient institute (that is, the institute which produces the greatest output for given inputs). Thus an institute with a technical efficiency score of 1.0 is efficient, while one with a score of 0.8 produces 80% of the outputs of an efficient peer.
- ✧ *Scale efficiency*, which describes the relationship between efficiency measured as outputs/inputs (that is, assuming constant returns to scale) and efficiency that takes into account the size of the institute. Thus a scale efficiency score of 0.5 indicates that the institute is operating at a very inefficient size, while a scale efficiency of 0.95 indicates that it is operating at near optimal size.

A strength of the method is that it does not rely on there being a mathematical relationship between the variables. Further, the method identifies peer groups, which are efficient units of a similar size (Agasisti & Johnes 2009).

In terms of limitations, the method will always identify as efficient at least one of the cases under examination. In reality they may all be inefficient (Abbot & Doucougliagos 2000). Furthermore, the choice and availability of inputs and outputs affects the efficiency scores obtained and, as noted earlier, statistical constraints limit the number of variables that can be analysed. This can lead to an over-simplification of the concept of efficiency. Finally, the results can be misleading if environmental differences (between institutions) are not accounted for (see Coelli et al. 2005). This is why it is important as a next stage to try to explain the variations in efficiency.

Explaining efficiency

Variations in efficiency can be attributed to environmental variables—generally things over which the institute has little control—and what we loosely call quality variables. Obvious environmental factors are location and student mix. For example, it may well be more expensive to deliver education and training in remote areas. Similarly, an institute with a large number of

² We are not including capital costs here as they would distort the efficiencies. Capital costs are not easily linked to outputs for a given year.

³ Full-year training equivalents are defined as the training activity undertaken by a student on a full-time basis for one year. One full year training equivalent equates to 720 hours of delivery. The scope of delivery includes TAFE and government providers (including fee for service), multi-sector higher education institutions, community providers and private providers.

⁴ We also fitted models using full-time training year equivalents. However, we do not present the results here because it is felt that successful outcomes are a more valid output than the quantity of training.

students with a disability is likely to face higher unit costs. The quality variables are intended to pick up quality differences; any comparison of efficiency implicitly assumes that the same product is being produced.

The approach we take is to run a simple regression, in which we attempt to explain efficiency in terms of a number of environmental and quality variables. Such an exercise will leave some variation unexplained, representing idiosyncratic factors: either factors that we have failed to take into account or factors that directly impact on efficiency, such as the quality of management. As with any statistical exercise, the number of observations is a constraint, and we are limited to variables that we have data on.

After some initial analysis the quality variables that were settled on were the proportion of students achieving their main reason for study and the proportion of students recommending the institution as a place of study. One point of interest in relation to these quality variables is that it is unclear how they relate to efficiency. On one hand, it may be more expensive to provide quality training. On the other, a well-run, efficient institute may produce more satisfied students. The environmental variables that were used were a remoteness indicator, the proportion of students reporting a disability, the proportion of part-time students, and average hours per student. It would be expected that the first three of these would be negatively related to efficiency (remoteness, large number of students with a disability, a large number of part-time students would all tend to increase costs), while the average hours per student would be positively related to efficiency because it is cheaper to teach fewer students for a given level of delivery.⁵

We summarise the variables in table 1.

Table 1 Input, output, quality and environmental factors considered in model

Input	Output	Quality	Environmental
Expenditure on salaries and related expenses	Full-year training equivalents (trades/technicians)	Percentage willing to recommend institution to others	Remoteness indicator
Other expenditure (excluding capital costs)	Full-year training equivalents (non-trade/technician) (Outputs adjusted for load pass rate)	Percentage of graduates achieved main reason for training	Percentage part-time students Percentage of students with a disability Average hours per student

Results of the data envelopment analysis⁶

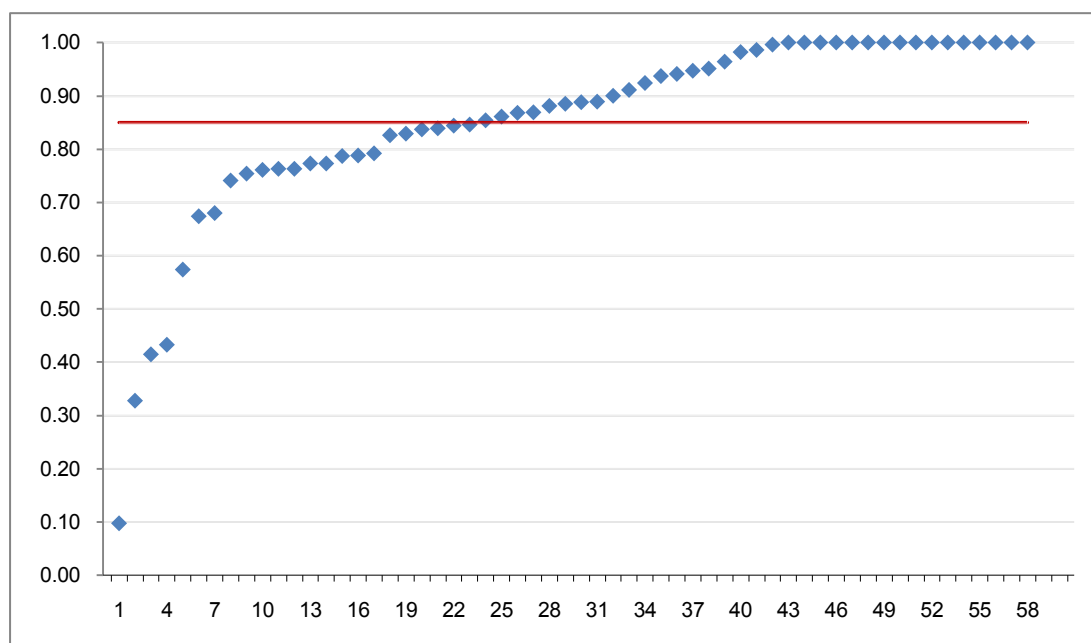
We can show graphically the variable returns to scale efficiency scores obtained by the Data Envelopment Analysis technique (institutes are sorted by efficiency).⁷ We focus on variable returns to scale as this method compares institutes of a similar size. The efficiency results presented below are for 2007. We also calculated efficiency scores for 2008, but there were a number of amalgamations of institutes in that year, creating some unusual circumstances. However, the 2008 scores are generally comparable with those of 2007.

⁵ Variables initially considered for inclusion in addition to the chosen variables were percentage of females, time to find job after training, percentage with English as second language, percentage of students with qualification less than Year 12, percentage employed before vs percentage employed after training

⁶ A summary of the inputs and outputs of the Data Envelopment Analysis is at appendix 1.

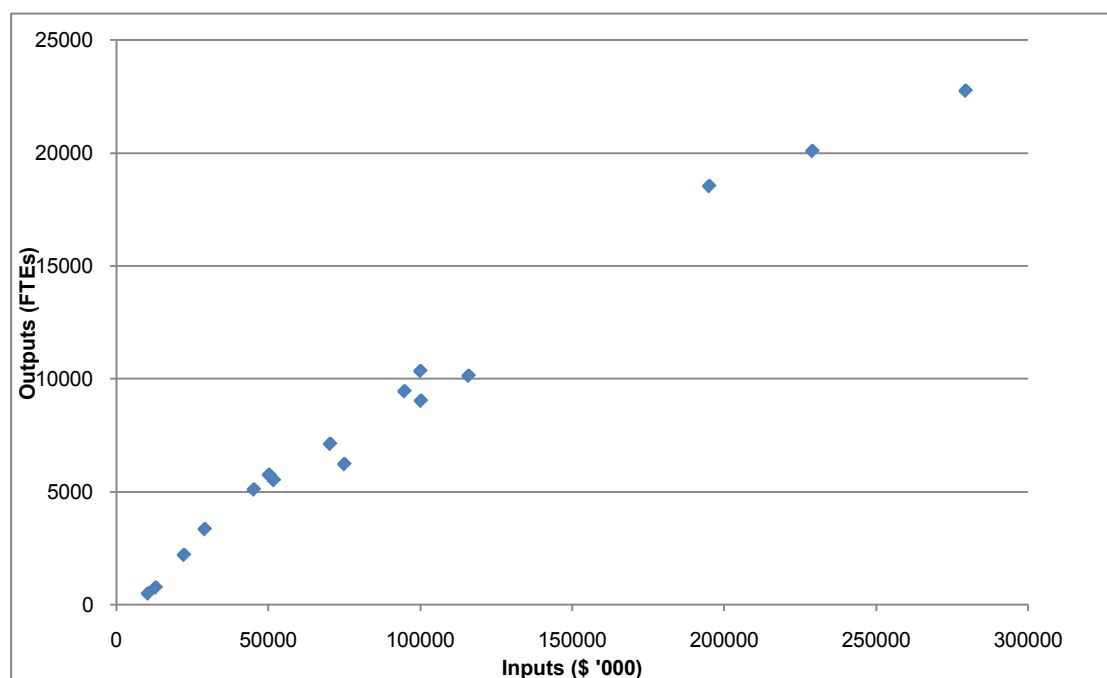
⁷ To perform the Data Envelopment Analysis, the DEAP 2.1 program, developed by Tim Coelli, was used. Subsequent statistical analysis was performed using the SAS 9.2 software package.

Figure 3 Variable returns to scale efficiency, in ascending order of efficiency



Note: Red line indicates efficiency mean of 0.85.

Figure 4 Efficient variable returns to scale frontier



The average efficiency score across all institutions was 0.85, with the scores ranging from a low of 0.10, to a high of 1.00 (for the 17 institutes which are the 'efficient' institutes). Fifty of the 58 institutes had an efficiency score of 0.75 or higher.

We can also map out the efficient institutes to give a graphical demonstration of the data envelope. We do this rather simplistically here by adding the two inputs and adding the two outputs. (The envelope is somewhat more complex when we have two inputs and two outputs.) We see from the figure that the efficient institutes follow a roughly curvilinear pattern, which is

the data envelope, suggesting that small and large institutions suffer an efficiency penalty. We come back to the issue of optimal size at the end of the paper.

Table 2 gives the results by institute. We have sorted the table by size (the total hours of delivery) in order to allow comparison between institutes of similar size, with the first institute being the smallest. The table also provides information on efficient peer institutes (those institutes that are efficient and are on the closest section of the data envelope). The numbers in brackets are the relative weighting of the peers, noting that all the peer weights for an institute add to 1.0.

We see that the efficient institutes can be small, medium-sized or large, reflecting the variable returns to scale methodology. We also note that the efficient peers of an institute are generally similar in size.

Table 2 Variable returns to scale efficiency scores and their peer institutes for TAFE institutes for 2007, sorted by size of the institute

	Efficiency	Efficient peers		Efficiency	Efficient peers
Institute01	1.00	-	Institute12	0.94	48 (0.76), 22 (0.24)
Institute27	0.10	26 (.09), 48 (.91)	Institute44	0.57	52 (0.03), 47 (0.22), 14 (0.75)
Institute54	0.43	48 (0.27), 29 (0.73)	Institute30	1.00	-
Institute29	1.00	-	Institute39	0.83	14 (0.12), 06 (0.60), 47 (0.28)
Institute37	0.33	47 (0.31), 58 (0.43), 01(0.26)	Institute06	1.00	-
Institute17	0.68	48 (.41), 29 (0.16), 01 (0.43)	Institute16	0.92	52 (0.18), 14 (0.05), 47 (0.77)
Institute20	0.95	47 (0.02), 01 (0.48), 58 (0.50)	Institute08	0.99	40 (0.49), 22 (0.12), 42 (0.38)
Institute57	0.88	47 (0.19), 01 (0.62), 58 (0.19)	Institute51	0.77	47 (0.42), 22 (0.12), 14 (0.35), 26 (0.11)
Institute58	1.00	-	Institute43	0.85	14 (0.40), 47 (0.21), 06 (0.40)
Institute36	0.94	52 (0.001), 47 (0.37), 01 (0.63)	Institute55	0.74	47 (0.08), 06 (0.05), 14 (0.87)
Institute38	0.76	47 (0.29), 01 (0.15), 58 (0.56)	Institute31	0.89	52 (0.12), 14 (0.55), 47 (0.34)
Institute53	0.77	52 (0.03), 01 (0.51), 47 (0.46)	Institute25	0.79	40 (0.44), 22 (0.41), 42 (0.16)
Institute34	0.87	52 (0.01), 30 (0.06), 01 (0.51), 47 (0.43)	Institute35	0.76	14 (0.51), 26 (0.01), 22 (0.1), 05 (0.38)
Institute56	0.84	47 (0.43), 30 (0.01), 40, (0.17), 01 (0.39)	Institute50	0.83	52 (0.22), 47 (0.03), 14 (0.75)
Institute04	0.42	47 (0.58), 06 (0.39), 48 (0.04)	Institute26	1.00	-
Institute48	1.00	-	Institute45	0.84	22 (0.36), 48 (0.14), 26 (0.27), 42 (0.22)
Institute15	0.84	47 (0.17), 06 (0.06), 48 (0.77)	Institute52	1.00	-
Institute49	0.89	26 (0.04), 48 (0.96)	Institute03	0.79	52 (0.13), 14 (0.86), 22 (0.02)
Institute33	0.96	48 (0.78), 42 (0.18), 01 (0.04)	Institute13	0.87	14(0.54), 05 (0.04), 06 (0.42)
Institute28	0.75	58 (0.26), 47 (0.64), 48 (0.10)	Institute07	0.85	14 (0.65), 05 (0.29), 22 (0.06)
Institute24	0.79	58 (0.06), 47 (0.65), 48 (0.29)	Institute11	0.95	30 (0.05), 47 (0.12), 22 (0.05), 14 (0.78)
Institute02	0.67	47 (0.79), 06 (0.03), 48 (0.19)	Institute14	1.00	-
Institute23	0.90	47 (0.57), 06 (0.05), 48 (0.38)	Institute05	1.00	-
Institute10	0.98	47 (0.23), 06 (0.09), 48 (0.69)	Institute09	1.00	-
Institute18	0.76	22 (0.09) , 48 (0.22), 42 (0.69)	Institute22	1.00	-
Institute41	0.89	52 (0.15), 47 (0.69), 48 (0.16)	Institute32	0.91	21 (0.15), 52 (0.14), 22 (0.51), 30 (0.19)
Institute42	1.00	-	Institute46	0.86	22 (0.86), 05 (0.14)
Institute40	1.00	-	Institute21	1.00	-
Institute47	1.00	-	Institute19	1.00	-

Note: the numbers in brackets are weights reflecting the importance of each efficient peer.

Explaining efficiency

As noted earlier, we use simple regression analysis to see the extent to which environmental and quality variables can explain the level of efficiency. Table 3 gives the results.

Table 3 Predictors of variable returns to scale efficiency—regression results

Variable	Parameter estimate	Standard error	t-value	Pr > t	Standardised estimate
<i>Environmental factors</i>					
Remoteness Indicator	-0.135	0.021	-6.36	<0.001	-0.743
Percentage reported disability	-0.015	0.008	-1.85	0.070	-0.193
Percentage part-time students	0.01	0.008	1.25	0.217	0.366
Average hours per student	0.001	0.001	1.75	0.085	0.556
<i>Quality factors</i>					
Percentage achieved main goal	0.006	0.003	2.2	0.033	0.245
Percentage would recommend Institution	0.019	0.012	1.65	0.106	0.215
Intercept	-2.58	1.676	-1.54	0.130	

The model explains about 57% of the variation in efficiency.⁸

Note: the remoteness variable is a constructed variable with mean 0 and standard deviation 1.

Our analysis found that the factor that explained most of the variation in the efficiency scores was the remoteness indicator. More specifically, institutes with high proportions of students in remote areas tend to have lower efficiency scores, indicating a higher cost of delivery for these institutes. These institutes also tend to have higher proportions of Indigenous students. Institutes with large numbers of students with a disability also tend to be less efficient. By contrast, having more part-time students and fewer full-time students helps efficiency, as does delivering to fewer students for a given level of training.

Interestingly, the two quality variables are positively associated with efficiency. Thus we presume that quality is not a cost. Rather, students are happy in efficiently run institutes.

While these associations are interesting, what really counts is the ‘kick’ the individual variables have. The standardised estimates in table 3 give one indication and show that the most important variable is remoteness, followed by average hours.⁹ Table 4 provides a more intuitive measure of the substantive importance of the variables. It shows the impact of the individual variables by taking the difference between the maximum and minimum value for each variable and multiplying by the coefficient (parameter estimate) for that variable.

⁸ In statistical jargon the adjusted R (squared) was 0.57.

⁹ The standardised estimate is the parameter less the mean divided by the standard deviation of the variable.

Table 4 Estimating the impact of quality and environmental variables on variable returns to scale efficiency

Variable	Coefficient	Min. value	Max. value	Difference min./max.	Impact (difference* coefficient)
<i>Environmental factors</i>					
Remoteness Indicator	-0.135	-0.48	4.25	4.73	-0.64
Percentage reported disability	-0.015	2.10	12.00	9.90	-0.15
Percentage part-time students	0.01	64.30	97.30	33.00	0.33
Average hours per student	0.001	123.30	510.00	386.70	0.39
<i>Quality factors</i>					
Percentage achieved main goal	0.006	55.97	87.76	31.79	0.19
Percentage would recommend Institution	0.019	87.00	96.80	9.80	0.19

This table shows that the remoteness indicator accounts for far more of the variation in efficiency scores than any of the other variables, followed by average hours per student. All variables, however, have a sizable impact on efficiency.

Finally, we focus on efficiency once we control for the environmental factors—we assume that these are beyond the control of the individual institute. One would be tempted to attribute this to the management of the institute, but it will also reflect environmental factors that we have not controlled for. For example, an institute may have to pay for the maintenance of historical buildings or have a series of campuses, which increases cost.

We split the relative ‘institutional efficiency’ score into two components. The first reflects the contribution from the quality variables, the second the unexplained component.¹⁰

In the earlier work we were presenting scores relative to 1.0 as being the most efficient. In this table, efficiency is now relative to what we would expect, given the remoteness and other environmental factors of the institute. Thus a score of zero means that the institute is as efficient as could be expected, while a positive score indicates that it is more efficient than could be expected (given the environmental factors we have accounted for). Similarly a negative value indicates that the institute is less efficient than could be expected. We see considerable variation, ranging from institute 44, which is 0.32 less efficient to institute 1, which is 0.49 more efficient than would be expected (given the environmental factors). On this basis, the institutes that are relatively efficient (a score of 0.1 or greater in table 5) are institutes 1, 5, 8, 12, 20, 26, 29, 33 48, and 58. The institutes that are relatively inefficient are 2, 3, 4, 7, 11, 27, 28, 35, 37, 44, 46, 53, and 55. This implies that 35 institutes are around average efficiency, once we take into account environmental factors.

¹⁰ In statistical jargon, the quality contribution is obtained by multiplying the institute's value of quality variable less the average value by the coefficient, and summing over the two quality variables. The unexplained component is the difference between actual and predicted values.

Table 5 Institutional efficiency relative to an institute of average efficiency, controlling for environmental factors, 2007

	Quality contribution	Unexplained component	Total		Quality contribution	Unexplained component	Total
Institute01	0.1	0.39	0.49	Institute30	-0.05	-0.02	-0.07
Institute02	0	-0.2	-0.2	Institute31	-0.01	0.08	0.07
Institute03	-0.01	-0.18	-0.19	Institute32	0.03	0.01	0.04
Institute04	0.01	-0.15	-0.14	Institute33	0	0.11	0.11
Institute05	-0.03	0.13	0.1	Institute34	0.11	-0.1	0.01
Institute06	-0.07	0.16	0.09	Institute35	0.03	-0.14	-0.11
Institute07	-0.07	-0.07	-0.14	Institute36	0.01	-0.02	-0.01
Institute08	0.03	0.1	0.13	Institute37	0.06	-0.2	-0.14
Institute09	0	0.05	0.05	Institute38	0.03	-0.11	-0.08
Institute10	0.05	0.02	0.07	Institute39	-0.01	-0.01	-0.02
Institute11	-0.08	-0.02	-0.1	Institute40	0.08	0.08	0.16
Institute12	0.09	0.1	0.19	Institute41	-0.01	0	-0.01
Institute13	-0.11	0.03	-0.08	Institute42	0.02	0.02	0.04
Institute14	0.02	0.05	0.07	Institute43	-0.06	-0.02	-0.08
Institute15	-0.05	-0.02	-0.07	Institute44	-0.06	-0.26	-0.32
Institute16	-0.12	0.1	-0.02	Institute45	0.03	-0.03	0
Institute17	0.06	-0.1	-0.04	Institute46	-0.06	-0.06	-0.12
Institute18	-0.09	0.08	-0.01	Institute47	-0.04	0.04	0
Institute19	-0.1	0.15	0.05	Institute48	0.07	0.04	0.11
Institute20	0.09	0.02	0.11	Institute49	-0.04	-0.04	-0.08
Institute21	-0.1	0.13	0.03	Institute50	0.06	-0.07	-0.01
Institute22	-0.04	0.1	0.06	Institute51	0.01	0.04	0.05
Institute23	0.04	0.04	0.08	Institute52	-0.03	0.07	0.04
Institute24	0.03	-0.05	-0.02	Institute53	-0.05	-0.07	-0.12
Institute25	-0.03	-0.03	-0.06	Institute54	0.05	0.01	0.06
Institute26	-0.04	0.14	0.1	Institute55	-0.07	-0.14	-0.21
Institute27	-0.09	-0.09	-0.18	Institute56	0.05	0.02	0.07
Institute28	0.06	-0.2	-0.14	Institute57	0.07	-0.1	-0.03
Institute29	0.05	0.14	0.19	Institute58	0.12	0.06	0.18

Optimal size

Finally, we can make some comments about the size of institutes. One of the prime issues that affects the relationship between outputs and inputs is size. Recall that the variable returns to scale data envelope shown in figure 2 was curvilinear. In table 6 we present the scale efficiency of each institute. The algorithm not only produces a measure of scale efficiency (with a value of 1.0 indicating that the institute is of an optimal size), but also shows whether efficiency would be improved by getting larger or smaller.

We see that the institutes of an optimal size are ranked 16, 21, 22, 25, 27, 28, 29, 32, 46 and 54 (rank 1 is the smallest). Thus optimal size covers a wide range. However, we do see that, for those seeking to improve their scale efficiency, all those, bar one, between 1 and 14 would need to become larger, while all those between 42 and 58 would need to become smaller.¹¹ Figure 5 shows this visually. Between these boundaries efficiency can be improved for some by getting larger and others getting smaller.

We also note that being small is a greater threat to efficiency than being large. Of those institutes that need to get smaller to improve efficiency, the lowest scale efficiency is 0.81. By contrast, the scale of efficiency of some institutes that should get larger is much lower, with 0.45 being the lowest.

Thus it is worth looking more closely at the effect of size at the bottom end of the size distribution. We examine the relationship between the hours of delivery of a given institute (as a proxy for size) and the institute's constant returns to scale efficiency scores (as these make no assumptions about size). This analysis provides us with a cut-off of a little less than three million teaching hours or 4170 full-year training equivalents. Up to this point returns to increasing size are greater than unity, while after this point the improvements in efficiency are less than unity. The relationship between hours of delivery (scaled) and efficiency is shown in figure 6.

¹¹ We ignore Institute 27 (the second smallest); it is clearly an outlier and the strange result that it would benefit from getting smaller is most likely driven by its very unbalanced delivery with virtually no trade offerings.

Table 6 Scale efficiency scores for TAFE institutes for 2007, sorted by size

Rank by size	Institute	Scale efficiency	Efficiency would increase if institute got:	Rank by size	Institute	Scale efficiency	Efficiency would increase if institute got:
1	Institute01	0.45	larger	30	Institute12	0.99	larger
2	Institute27 ¹	0.97	smaller	31	Institute44	0.93	smaller
3	Institute54	0.78	larger	32	Institute30	1.00	-
4	Institute29	0.58	larger	33	Institute39	0.92	smaller
5	Institute37	0.91	larger	34	Institute06	0.90	smaller
6	Institute17	0.83	larger	35	Institute16	0.99	smaller
7	Institute20	0.77	larger	36	Institute08	0.97	larger
8	Institute57	0.80	larger	37	Institute51	0.91	smaller
9	Institute58	0.89	larger	38	Institute43	0.92	smaller
10	Institute36	0.86	larger	39	Institute55	0.92	smaller
11	Institute38	0.92	larger	40	Institute31	0.93	smaller
12	Institute53	0.91	larger	41	Institute25	0.99	larger
13	Institute34	0.91	larger	42	Institute35	0.86	smaller
14	Institute56	0.93	larger	43	Institute50	0.92	smaller
15	Institute04	0.95	smaller	44	Institute26	0.97	smaller
16	Institute48	1.00	-	45	Institute45	0.98	smaller
17	Institute15	0.99	smaller	46	Institute52	1.00	-
18	Institute49	0.99	smaller	47	Institute03	0.91	smaller
19	Institute33	0.98	larger	48	Institute13	0.91	smaller
20	Institute28	0.99	larger	49	Institute07	0.88	smaller
21	Institute24	1.00	-	50	Institute11	0.90	smaller
22	Institute02	1.00	-	51	Institute14	0.92	smaller
23	Institute23	0.99	smaller	52	Institute05	0.86	smaller
24	Institute10	0.98	smaller	53	Institute09	0.84	smaller
25	Institute18	1.00	-	54	Institute22	1.00	-
26	Institute41	0.98	larger	55	Institute32	0.93	smaller
27	Institute42	1.00	-	56	Institute46	0.87	smaller
28	Institute40	1.00	-	57	Institute21	0.90	smaller
29	Institute47	1.00	-	58	Institute19	0.81	smaller

Note: 1 This institution represents a significant outlier in relation to the balance of its outputs. It has virtually no trade training. This lack of balance seems to be the reason why we get the unexpected finding that it should become smaller, despite being the second smallest institute.

Figure 5 Whether an institute should be larger or smaller to become more efficient, by size of institute

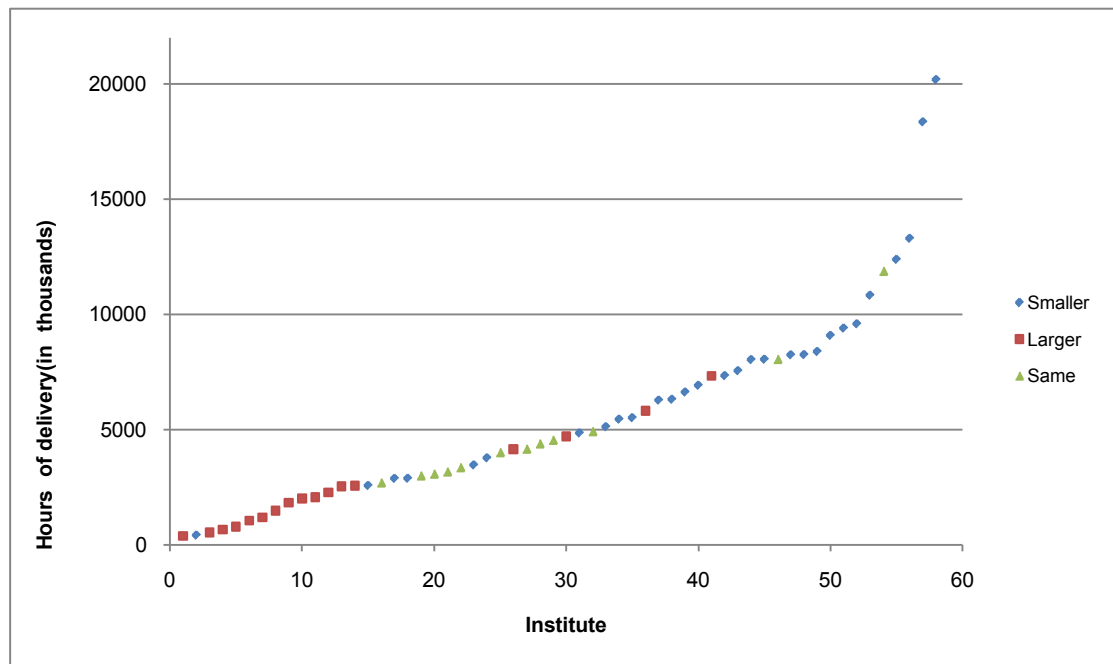
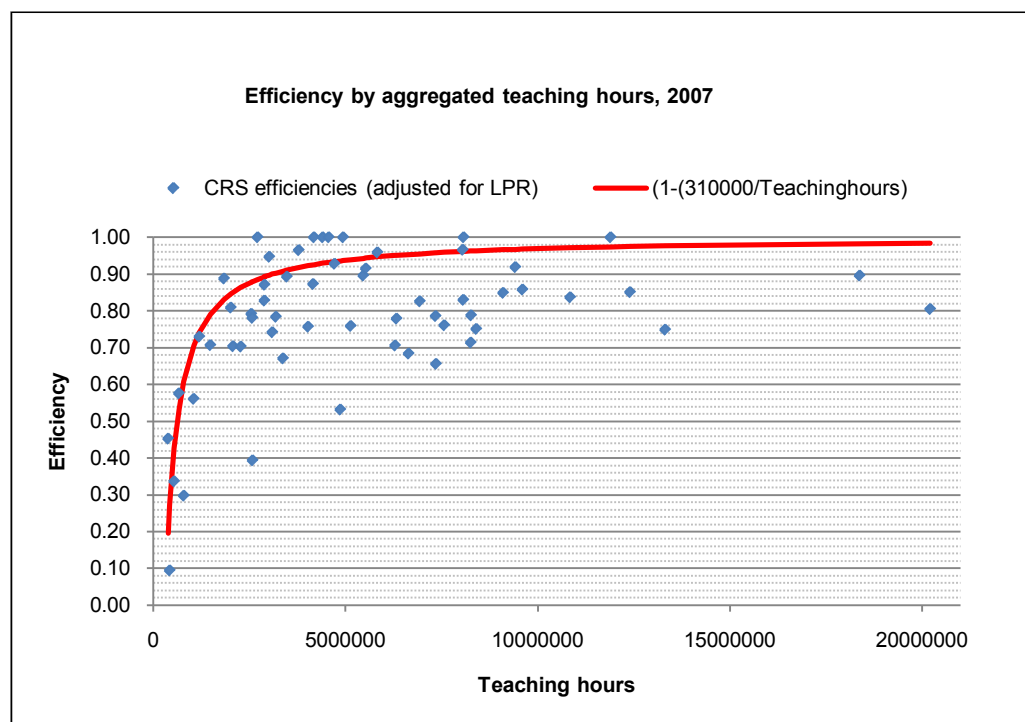


Figure 6 Constant returns to scale efficiency, by size of institute



Final comments

This study has found considerable variation in the efficiency of institutes. The variation arises from two main sources—the size of the institute and a remoteness indicator (which incorporates the Indigenous status of students). A number of other environmental variables also affect efficiency, notably, the number of students with a disability, the proportion of part-time students and the average hours per student. Thus, in comparing the efficiency of institutes, we must be careful to account for these variables; otherwise the comparisons are specious.

However, it is clear that considerable variation still exists when we account for size and other environmental variables. A small proportion is associated with a number of quality variables, with quality being positively correlated with efficiency, suggesting that efficient institutes on average provide better-quality training. This leaves a substantial amount of variation unexplained, and this unexplained variation in efficiency is due to the management of the institute, or specific environmental factors that we have not observed.

The power in these results is that, while the statistical techniques have limitations, they enable institutes to benchmark with similar institutes. The results will provoke questions if not the answers. They should also be informative to the planning of institutes because they give an indication of the optimal size of an institute for efficiency, and the penalty attached to being too small or too large.

Subsequent to the analysis conducted for this paper, data checking revealed some issues which brought home to us the reality of this type of analysis, based as it is on only 58 cases. Change to the data of one institute had a minor impact on some aspects of the analysis but a major impact on others. The analysis with revised data (not reported in this paper) confirmed the significance of remoteness among the environmental factors and ‘achieved main goal’ among the quality factors. The other variables became insignificant, indicating that our explanation of relative efficiency is quite sensitive.

Some of the limitations can be overcome by increasing the number of cases by accumulating data over two or three years. This would add stability to the analysis. Thus it would be useful to revisit the analysis in a couple of years when we have done this.

References

- Abbott, M & Doucouliagos, C 1998, *A DEA analysis of the efficiency of Victorian technical and further education institutes*, Working paper series no.9802, Faculty of Business Law, Deakin University, Ballarat.
- Abbott, M & Doucouliagos, C 2000, 'Amalgamations and the efficiency of Queensland TAFE institutes', *Australian and New Zealand Journal of Vocational Education Research*, vol.8, no.2, pp.1–19.
- Agasisti, T & Johnes, G 2009, 'Beyond frontiers: Comparing the efficiency of higher education decision-making units across more than one country', *Education Economics*, vol.17, no.1, pp. 59–79.
- Carrington, R, Coelli, T & Rao, P 2004, 'Measuring the performance of Australian universities: Conceptual issues and initial results', Asia-Pacific Productivity Conference 2004, University of Queensland, Brisbane, 14–16 July.
- Coelli, T, Prasada Rao, DS, O'Donnell, CJ & Battese, GE 2005, *An introduction to efficiency and productivity analysis*, 2nd edn, Springer, New York.
- Cooper, W, Seiford, L & Zhu, J 2004, 'Data envelopment analysis: Models and interpretations', in *Handbook on data envelopment analysis*, eds W Cooper, L Seiford & J Zhu, Kluwer Academic Publisher, Boston.

Appendix 1

Table A1 Summary table of inputs, outputs, efficiencies, and efficient peers, 2007

	Input 1	Input 2	Output 1	Output 2	CRS	VRS	SCALE	Efficient peers
	Salaries	Other exp	Trades/tech <i>LPR adjusted</i>	Non-trades/tech <i>LPR adjusted</i>	Effic. <i>LPR adjusted</i>	Effic. <i>LPR adjusted</i>	Effic. <i>LPR adjusted</i>	
Institute01	6 866 817	3 628 890	193	294	0.45	1.00	0.45	-
Institute27	24 512 000	20 442 000	12	323	0.10	0.10	0.97	26, 48
Institute54	11 262 780	7 369 162	14	526	0.34	0.43	0.78	48, 29
Institute29	7 985 724	5 030 853	114	637	0.58	1.00	0.58	
Institute37	19 261 328	13 668 857	275	666	0.30	0.33	0.91	47, 58, 01
Institute17	12 603 626	9 485 537	215	944	0.56	0.68	0.83	48, 29, 01
Institute20	11 611 162	6 980 023	355	1 034	0.73	0.95	0.77	47, 01, 58
Institute57	13 794 000	9 732 000	497	1 099	0.71	0.88	0.80	47, 01, 58
Institute58	15 079 000	7 237 000	477	1 719	0.89	1.00	0.89	-
Institute36	17 332 091	11 788 655	763	1 517	0.81	0.94	0.86	52, 47, 01
Institute38	19 688 000	9 996 000	640	1 629	0.70	0.76	0.92	47, 01, 58
Institute53	21 390 000	11 783 000	847	1 576	0.70	0.77	0.91	52, 01, 47
Institute34	22 162 000	9 716 000	1 085	1 636	0.79	0.87	0.91	52, 30, 01, 47
Institute56	24 731 166	10 399 547	1 112	1 945	0.78	0.84	0.93	47, 30, 40, 1
Institute04	39 744 000	31 681 000	627	1 937	0.39	0.42	0.95	47, 06, 48
Institute48	20 342 000	8 808 000	522	2 817	1.00	1.00	1.00	-
Institute15	24 554 127	10 745 973	654	2 680	0.83	0.84	0.99	47, 06, 48
Institute49	22 273 348	12 169 274	382	2 687	0.87	0.89	0.99	26, 48
Institute33	22 918 476	9 167 393	653	2 766	0.95	0.96	0.98	48, 42, 01
Institute28	28 465 000	14 237 000	1 033	2 427	0.74	0.75	0.99	58, 47, 48
Institute24	29 650 266	14 033 738	1 097	2 711	0.78	0.79	1.00	58, 47, 48
Institute02	32 717 000	16 061 000	1 073	2 522	0.67	0.67	1.00	47, 06, 48
Institute23	30 221 715	13 578 012	1 187	3 232	0.89	0.90	0.99	47, 06, 48
Institute10	26 090 000	18 036 000	858	3 273	0.97	0.98	0.98	47, 06, 48

	Input 1	Input 2	Output 1	Output 2	CRS	VRS	SCALE	Efficient peers
	Salaries	Other exp	Trades/tech <i>LPR adjusted</i>	Non-trades/tech <i>LPR adjusted</i>	Effic. <i>LPR adjusted</i>	Effic. <i>LPR adjusted</i>	Effic. <i>LPR adjusted</i>	
Institute18	41 858 469	13 584 066	1 178	3 294	0.76	0.76	1.00	22, 48, 42
Institute41	34 896 000	17 993 000	1 855	2 940	0.87	0.89	0.98	52, 47, 48
Institute42	33 416 483	11 882 677	1 455	3 640	1.00	1.00	1.00	-
Institute40	38 327 531	13 559 472	2 448	3 059	1.00	1.00	1.00	-
Institute47	35 126 669	15 157 914	1 865	3 884	1.00	1.00	1.00	-
Institute12	57 965 692	16 184 931	554	5 119	0.93	0.94	0.99	48, 22
Institute44	61 263 000	36 079 000	1 574	3 767	0.53	0.57	0.93	52, 47, 14
Institute30	55 285 611	19 788 005	5 544	675	1.00	1.00	1.00	
Institute39	47 223 717	22 049 691	1 253	4 628	0.76	0.83	0.92	14, 06, 47
Institute06	48 598 000	21 797 000	1 087	6 032	0.90	1.00	0.90	-
Institute16	41 992 785	31 486 574	2 312	3 761	0.92	0.92	0.99	52, 14, 47
Institute08	68 168 062	16 043 686	2 330	4 506	0.96	0.99	0.97	40, 22, 42
Institute51	64 748 772	24 940 070	1 942	5 229	0.71	0.77	0.91	47, 22, 14, 26
Institute43	53 753 181	45 090 300	1 662	5 200	0.78	0.85	0.92	14, 47, 06
Institute55	65 053 000	35 354 000	2 026	5 257	0.68	0.74	0.92	47, 06, 14
Institute31	56 830 000	34 598 000	2 493	5 186	0.83	0.89	0.93	52, 14, 47
Institute25	89 545 694	23 780 819	2 602	5 916	0.79	0.79	0.99	40, 22, 42
Institute35	78 651 321	36 934 632	1 968	6 485	0.66	0.76	0.86	14, 26, 22, 05
Institute50	66 570 000	43 959 000	2 781	5 435	0.76	0.83	0.92	52, 47, 14
Institute26	68 395 701	26 468 087	1 158	8 292	0.97	1.00	0.97	-
Institute45	85 443 786	25 369 328	2 096	7 106	0.83	0.84	0.98	22, 48, 26, 42
Institute52	63 744 274	36 518 591	5 125	3 902	1.00	1.00	1.00	
Institute03	69 339 000	36 869 000	2 534	5 573	0.71	0.79	0.91	52, 14, 22
Institute13	60 318 237	37 239 832	1 809	5 986	0.79	0.87	0.91	14, 05, 06
Institute07	74 739 000	36 570 000	2 254	6 939	0.75	0.85	0.88	14, 05, 22
Institute11	68 222 000	29 170 000	2 847	6 596	0.85	0.95	0.90	30, 47, 22, 14
Institute14	68 715 000	31 446 000	2 899	7 447	0.92	1.00	0.92	-
Institute05	72 001 000	43 938 000	1 599	8 536	0.86	1.00	0.86	-

	Input 1	Input 2	Output 1	Output 2	CRS	VRS	SCALE	Efficient peers
	Salaries	Other exp	Trades/tech <i>LPR adjusted</i>	Non-trades/tech <i>LPR adjusted</i>	Effic. <i>LPR adjusted</i>	Effic. <i>LPR adjusted</i>	Effic. <i>LPR adjusted</i>	
Institute09	85 629 000	43 954 000	2 893	8 850	0.84	1.00	0.84	14, 05
Institute22	155 765 437	39 316 496	4 886	13 656	1.00	1.00	1.00	-
Institute32	126 441 783	36 843 133	4 872	8 809	0.85	0.91	0.93	21, 52, 22,30
Institute46	143 742 066	45 579 220	3 707	11 122	0.75	0.86	0.87	22, 05
Institute21	178 153 601	50 855 591	6 906	13 190	0.90	1.00	0.90	-
Institute19	216 145 946	63 289 329	6 850	15 918	0.81	1.00	0.81	-

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