PREDICTIVE ANALYTICS GROUP

Essential Services Commission

Local Government – Measuring Productivity Using a Direct Method

Final Report
June 2017

Inherent Limitations

This report has been prepared as outlined in Section 1 of this report.

No warranty of completeness, accuracy or reliability is given in relation to the statements and representations made by, and the information and documentation provided by, the Department of Infrastructure and Regional Development (the Department) consulted as part of the process.

Predictive Analytics Group (PAG) has indicated within this report the sources of the information provided. We have not sought to independently verify those sources unless otherwise noted within the report.

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The findings in this report have been formed on the above basis.

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Forecasts and simulations

In the course of our work, forecasts and/or simulations have been prepared on the basis of assumptions and methodology which have been described in our report. It is possible that some of the assumptions underlying our forecasts and/or simulations may not materialise. Nevertheless, we have applied our professional judgement in making these assumptions, such that they constitute an understandable basis for estimates and projections. Accordingly, readers of this Report must appreciate that, to the extent that certain assumptions do not materialise, our estimates and projections may vary.

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Glossary

Constant returns to scale (CRS)	The assumption that the relationship between inputs and outputs is constant. Namely, an increase in inputs results in commensurate and equal change in outputs.
Efficiency	Degree to which the observed use of resources to produce outputs of a given quality matches the optimal use of resources to produce outputs of a given quality.
Input oriented	Type of DEA. An input oriented DEA assumes that entities only have control over the amount of inputs and not the amount of outputs.
Output oriented	Type of DEA. An output oriented DEA assumes that entities only have control over the amount of outputs and not the amount of inputs.
Production frontier	The line or curve plotting the minimum amount of an input (or combination of inputs) required to produce a given quantity of output (or combination of outputs).
Productivity	Measure of the physical output produced from the use of a given quantity of inputs. This may include all inputs and outputs (Total Factor Productivity) or a subset of inputs and outputs (Partial Productivity). Productivity varies as a result of differences in technological change and differences in technical efficiency.
Returns to scale	Relationship between outputs and inputs. Returns can be constant, increasing or decreasing depending on whether output increases in proportion to, more or less than inputs, respectively. In the case of multiple inputs and outputs, this refers to how outputs change when there is an equi-proportionate change in all inputs.
Scale efficiency	The extent to which an entity can take advantage of returns to scale by altering its size towards optimal scale (which is defined as the region in which there are constant returns to scale in the relationship between inputs and outputs).

Technical efficiency	Conversion of inputs into outputs. Technical efficiency is determined by the difference between the observed ratio of combined quantities of an entity's output to input ratio achieved by best practice. It can be expressed as the potential to increase quantities of outputs from given quantities of inputs, or the potential to reduce quantities of inputs used in producing given quantities of outputs.
Technological change	The expansion or contraction of efficiency due to technological changes (i.e. the adoption of new technologies resulting in the expansion or contraction of the production frontier). In essence, this variable indicates how innovative an entity has been with their technology.
Variable returns to scale (VRS)	The assumption that the relationship between inputs and outputs is an increasing or decreasing one.

1 Executive Summary

1.1 Background and Scope

The Essential Services Commission (**the Commission**) engaged Predictive Analytics Group (**PAG**) in December 2016 to measure the productivity of local governments in Victoria using a direct method. In this analysis, productivity is defined as the rate of output per unit of input.

In our analysis, we assume that local government take outputs as fixed (or exogenous) but they have a large degree of control over the level of inputs used. To estimate local government efficiency, we employ Data Envelopment Analysis (DEA), which allows for the measurement of multiple inputs and outputs for the production point estimates of relative efficiency. Furthermore, Data Envelopment Analysis (DEA) is considered a robust method for obtaining measures on the relative performance of similar entities.

As noted by the Steering Committee for the Review of Commonwealth/State Service Provision, DEA is a robust methodology for government service provision as it can handle multiple inputs and outputs and does not require information on output prices. The Steering Committee notes that DEA should be considered 'a starting point for assessing the efficiency of service providers'. In this vein, this report gives multiple methods of computing a final efficiency factor which allows for the Commission to use their knowledge of the sector to determine the best form an efficiency factor should take.

The Commission considers Data Envelopment Analysis (DEA) to represent a direct approach:

- DEA is defined as a linear programming approach to compute the efficiencies of entities by forming a frontier based on the relative efficiency of the various entities to each other.

Two key stages define the work requirements of this analysis; namely:

- Stage 1: The development of Total Factor Productivity (TFP) models via the DEA methodology using the existing Victorian Grants Commission (VGC) data.
- Stage 2: Calculation refinement and sensitivity analysis.

The specific tasks followed to facilitate each stage of the analysis are outlined below.

1.2 Approach

Local governments provide a wide variety of services to their municipalities including, for example, public health, traffic, parking, road maintenance, waste collection, community services, local laws and recreation and culture. The scale and scope of activities undertaken by individual local governments may vary depending on the size and nature of their municipality. As such, a robust analysis into the Victorian local government sector should acknowledge that each local government may have different characteristics. To facilitate our analysis, the 79 local governments under examination will be grouped as follows:

- Interface
- Large Rural
- Metropolitan
- Regional Centre
- Small Rural

The analysis outlined in this report follows two major stages. Namely:

1. **Stage 1 – Data consolidation and review.**

This stage includes the following tasks:

- Compile necessary datasets including the aforementioned VGC as well as publicly available data regarding Victorian local governments.
- Review the data sets to determine what information is suitable to enable meaningful comparisons to be made among local governments.
- Liaise with a technical working group (comprised of interested stakeholders) convened to discuss issues related to these measures.

It is also required that preliminary work be undertaken to calculate productivity levels in the local government sector. This includes:

- Developing the data requirements to calculate productivity trends using a total factor productivity (TFP) approach. This involves selecting appropriate data from the VGC data as well as ensuring the consistency and veracity of the data reported.
- Calculating indicative productivity levels using a suitable TFP approach. Productivity may be measured across the whole sector or by meaningful sub group.[1]

2. **Stage 2 – Measuring Productivity using Quantitative Methods**

This stage involves refining the DEA calculations undertaken in the previous stage to incorporate any new assumptions or updated information in light of consultation with the sector.

1.3 Data Envelopment Analysis

DEA is a method of computing the efficiency and productivity of an entity. The concept of 'efficiency' is used to examine or measure the performance of a system or process. Typically, an efficient system or process is one that uses the lowest amount of inputs to create the greatest amount of outputs (contingent on quality). Productivity can be thought of as the measure of efficiency. It is computed by dividing average output per period by the total costs incurred or resources (capital, material and labour) consumed in that period. *Total factor productivity (TFP)* is a measure of productivity which encapsulates all inputs and outputs. TFP will be used to assess the change in efficiency of local governments from year to year.

In this report, DEA is used to assess the efficiency of local governments[2]. Through this approach a *production frontier* is created. The production frontier is a line or a curve plotting the minimum amount of an input (or combination of inputs) required to produce a given quantity of outputs of a given quality. A hypothetical example of a single-input and single-output is given below in Figure 1-1

[1] Subgroups of Victorian local governments are defined as: Interface, Large Rural, Metropolitan, Small Rural and Regional Centre.

[2] This is achieved via the application of a linear programming approach. Linear programming is a set of linear mathematical equations for which an optimal solution can be obtained subject to constraints.

Figure 1-1 - A hypothetical single-input and single-output production frontier[3]

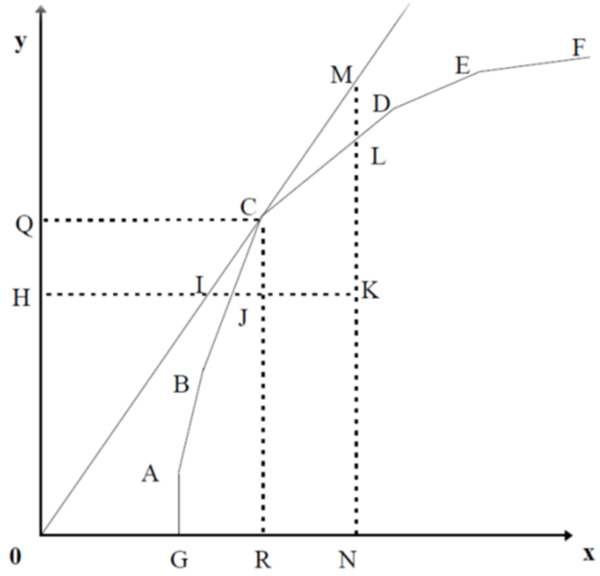


Figure 1-1 shows two types of production frontiers, a constant returns to scale (CRS) frontier, and a variable returns to scale (VRS) frontier. The difference between the two types of frontiers is that a CRS frontier assumes that for every unit of input, there is a commensurate unit of output. If this not the case (which in some cases can be due to the fact the entity is not scale efficient), then for every unit of input, there may be a higher or lower level of output than a unit output. In other words, under the CRS assumption the level of output is proportionate to the level of input, whereas under the VRS assumption the level of output is not proportionate to the level of input. Another way of stating this is that CRS implies a one to one relationship, whereas VRS can have more or less output per unit of input.

The CRS frontier in Figure 1-1 is denoted by the line 0M. Entities on this line are considered to be fully efficient. For example, the entity represented by the point C would be considered fully efficient. The VRS frontier in Figure 1-1 is shown by the line GABCDEF. Entities on this curve would be considered fully efficient. A local government's efficiency score is measured relative to the CRS frontier or the VRS frontier. Efficiency scores are calculated within a range of zero and one. If the local government is on the production frontier, it has an efficiency of one. The further away a local government is from the production frontier, the lower the efficiency score it has.

[3] Worthington and Dollery (2001)

1.4 A brief review of the literature

An extensive review of the DEA literature dating back to 1957 was conducted. Recent literature regarding the application of DEA to a variety of contexts, including Australian local government efficiency analysis, was also reviewed. This review of the literature found that the estimation of efficiency scores is typically undertaken using the DEA (VRS) method rather than the DEA (CRS). The main reason for this is that DEA (VRS) employs a non-linear frontier to estimate efficiency scores and thus does not assume, *a priori*, that all local governments are operating at optimal scale efficiency (see for example, Banker, Charnes and Cooper (1984) or the Steering Committee for the Review of Commonwealth/State Service Provision Report (1997)[4]). It should be also noted that DEA is considered a standard methodology for computing efficiencies. It has been used in many studies regarding Australian local government analysis. These studies include both academic papers and government reports. See, for example:

- Worthington and Dollery (2001): NSW municipal waste management.
- Worthington and Dollery (2000): Efficiency of NSW local governments.
- Worthington (2000): Cost efficiency in Australian local government.
- Drew, Kortt and Dollery (2015): NSW local government efficiency.
- Woodbury and Dollery (2004): NSW municipal water services.
- Gregan and Bruce (1997): Report into the technical efficiency of hospitals in Victoria.

In this report, the number of households and number of businesses, as well as road length are used as outputs. This is owing to the fact that Victorian local governments primarily provide services to households and businesses, as well as being responsible for the maintenance of roads. This has been noted in studies such as Drew and Dollery (2014). As noted, Australian local governments in general provide services to property. Drew and Dollery (2014) do note that some functions not traditionally involved in the domain of local government have become a part of local government function. However, the study states that 'these emerging services…are still relatively insignificant compared with the traditional services to property remit of Australian local governments'. However, Drew and Dollery (2014) find that the number of households and businesses is in fact more representative of the true output of Victorian local governments.

A salient feature of DEA is that it is a relative measure. The technique uses the available local governments in order to assess which are the most efficient, relative to the other local governments. The implication of this is that even if a local government is judged by the DEA methodology to be fully efficient (or 'on the frontier'), it is still possible for the local government to become more efficient and shift the frontier further forward. As such, any resultant X-factor does not necessarily penalise more efficient local governments, only spur them to push the frontier further forward.

1.5 Method

This section outlines the various quantitative methods used to facilitate the quantitative analysis outlined in this report.

In addition to the data provided by the Commission, PAG also obtained data pertaining to the demographic and economic variables of Victorian local governments from the Australian Bureau of Statistics (ABS) and the Australian Government Department of Employment.

[4] Available at http://www.pc.gov.au/research/supporting/data-envelopment-analysis

The next stage involved applying DEA to the data for the 2015-16 financial year. Five models of input and output pairings (outlined in Table 1-1), were examined. A production frontier for each model was computed and technical efficiencies for each local government were computed under each model.

Total Factor Productivity was then computed from the 2010-11 financial year to the 2015-16 financial year. Total Factor Productivity is represented by the Malmquist index. The Malmquist index provides an indication as to whether the local governments are becoming more or less efficient over time.

Efficiency factors were then calculated. These were based on the technical efficiencies for the 2015-16 financial year and the Malmquist index from the 2010-11 financial year to the 2015-16 financial year. A number of scenarios were utilised for the consideration of the Commission as to which level of efficiency increases the Commission deems appropriate.

Finally, sensitivity analysis was conducted. This involved determining the impact that an increase or decrease in inputs would have upon the efficiency scores of local governments.

1.6 Key Findings

DEA 2015 results

Table 1-1 below summarises the efficiency results calculated for the 2015-16 financial year using DEA constant returns to scale (CRS); and DEA variable returns to scale (VRS). DEA (CRS) assumes a linear frontier. The frontier is the line which indicates full efficiency. Full efficiency can be considered as a local government being optimal in terms of its ability to convert its inputs into outputs relative to other local governments.

DEA (VRS) is based on a non-linear frontier as it assumes that not all local governments are operating at optimal scale efficiency.[5] As such, the efficiencies calculated under DEA (VRS) tend to be higher than for DEA (CRS).

Table 1-1 - DEA 2015-16 Results (Single Group Analysis)

Model Number	Model Specification		Mean Technical Efficiency			
	Inputs	Outputs	DEA (CRS)	No. of Local Gov. on the frontier	DEA (VRS)	No. of Local Gov. on the frontier
1	Staff ($) + Capital ($)	H/holds + Businesses + Roads	0.74	9	0.81	20
2	Staff (FTE) + Capital ($)	H/holds + Businesses + Roads	0.71	6	0.79	17
3	Staff ($) + Capital ($)	H/holds + Businesses + Roads + Waste	0.76	11	0.83	23

[5] Scale efficiency can be defined as when, for every unit input, there is a corresponding unit output for a local government. Local governments that are not scale efficient, can have more or less than a unit output for each unit input, or for each unit input, more or less than a corresponding unit output.

Model Number	Model Specification		Mean Technical Efficiency			
	Inputs	Outputs	DEA (CRS)	No. of Local Gov. on the frontier	DEA (VRS)	No. of Local Gov. on the frontier
4	Capital ($) + Operating Expenses (excl. Depreciation) ($)	H/holds + Businesses + Roads	0.73	6	0.81	18
5	Operating Expenses (excl. Depreciation) ($) + Depreciation ($)	H/holds + Businesses + Roads	0.76	6	0.82	15

Efficiency scores range from 71% (DEA (CRS) Model 2) to 83% (DEA (VRS) Model 3). A robust model is one which encapsulates the following attributes:

1. It includes the broadest range of possible inputs which are common to all local governments;
2. It accounts for the full scale of local government operations; and
3. It covers the broadest range of possible outputs (in terms of services provided) which are common to all local governments.
    a. For example, staffing costs, whether in dollar terms or fulltime equivalent units (FTE), and capital outlays are common to all local governments and account for the majority of local government inputs.

The model specifications which include all three attributes are Models 1, 2 and 3. An alternative specification, which also covers a broad range of local government inputs, is the use of capital outlays and operating expenses (excluding depreciation), denoted by Model 4, or operating expenses (excluding depreciation) and depreciation, denoted by Model 5.

It is important that the broadest possible specification of outputs (in other words, services to whom the services represented by the inputs were rendered) are incorporated into the model. Services are primarily rendered to households and businesses. In addition, all local governments have the necessity of servicing roads in their local government area. To account for the services rendered to these entities, Models 1, 2, 4 and 5 were specified. In addition to these model specifications, it was considered of value to construct a model which accounts for the amount of waste collected[6]. This is a service common to all local governments. To this end, Model 3 was specified.

According to the academic literature relating to the analysis of local government efficiency, the specification of inputs and outputs as specified in Model 1, is considered the most comprehensive and succinct (see Drew, Kortt and Dollery (2015)). It is comprehensive because it covers all inputs and outputs considered relevant to local governments. Further, it does not double count certain aspects of local government inputs or outputs. For example, if population were included as an additional output in addition to the number of households, this could be considered double counting the 'number of households' output measure.

[6] This was the amount of waste collected according to the VLGAS Region by Council data set

Drew, Kortt and Dollery (2015) specify a number of additional reasons why Model 1 is the preferred model. Firstly, ‘staffing costs’ provide a more robust measure of the input that staff members have into a local government’s operations compared with ‘staff FTE’ measure (as is used in Model 2). This is because not all staff are paid the same rate and salary - factors that are considered to reflect responsibility, experience and quality of work.

Furthermore, borrowing costs should be excluded as an input as these may act to artificially inflate the inputs rather than contribute to the outputs. The inclusion of borrowing costs may penalise those with debt as the borrowings may not directly map to use for outputs. In addition, the number of households and businesses is considered to be a more stable representation of outputs than population and should be used in preference to population as an output.

Finally, given the inconsistent treatment of depreciation among local governments, depreciation should be excluded as an input due to the fact that for different local governments the figures have different meanings depending on how the local government chose to report the figure. As such, the specification of Model 1 in terms of inputs and outputs is considered in the literature of Australian local government efficiency to be the preferred model specification.

Furthermore, compiling additional inputs or outputs for the purposes of DEA may have a minimal or even negligible impact on the efficiency scores of local governments. This is owing to the fact that the additional data only accounts for a relatively small part of local government operations.

Furthermore, the inputs considered in the above models cover a broad spectrum of local government operations. While the cost of specific services to people may not be included separately, they are still included under headings such as Operating Expenses (excluding Depreciation) or Staff Costs.

It should be noted that the results presented in Table 1-1 are averages of all 79 local governments and do not represent each local government’s performance on an individual level.

It should also be noted that in this report, the DEA used is that of an input oriented DEA. This assumes that the local government has a large degree of control over its inputs and takes outputs to be exogenous. This assumption has a realistic basis in that local governments can control their spending (or inputs), but do not have such a great control over the number households and businesses in the municipality (or outputs). This is in line with research into the efficiency of local governments (see, for example, Worthington and Dollery (2001)).

The model with the highest number of local governments being fully efficient is Model 3 under the DEA (VRS) framework. This framework has 23 local governments being stipulated as fully efficient. In addition this framework had a mean technical efficiency score of 83%. The model under the DEA (VRS) framework with the highest mean technical efficiency scores is Model 3, with a mean technical efficiency scores of 83%.

The model with the lowest mean technical efficiency is Model 2 under the DEA (CRS) framework. This model and framework has a mean technical efficiency of 71%. Similar to the results under the DEA (VRS) framework, the models with the highest mean technical efficiency scores under the DEA (CRS) framework are Models 3 and 5. These models have mean technical efficiency scores of 76% under the DEA (CRS) framework.

The mean technical efficiencies presented in Table 1-1 indicate that although some local governments are fully efficient (relative to other local governments), the majority of local governments have room for improvement. The mean technical efficiencies are well above 50%, indicating that local governments are generally performing well. Using these numbers it will be possible to give an efficiency factor which is achievable for local governments to attain.

Figure 1-2 below shows the technical efficiencies for Model 1 DEA (VRS) in which local governments are considered as a single group. From Figure 1-2 it can be seen that under Model 1 DEA (VRS) there are 20 local governments that are fully efficient. The remaining 59 local governments have efficiency scores ranging from 51.2% to approximately 97.33%. The local government with the lowest efficiency score is Regional Centre 7, with a score of 51.2%. The local government with an efficiency score of 97.33% is Metropolitan 17. The mean efficiency score of all local governments under the Model 1 DEA (VRS) framework is 81%.

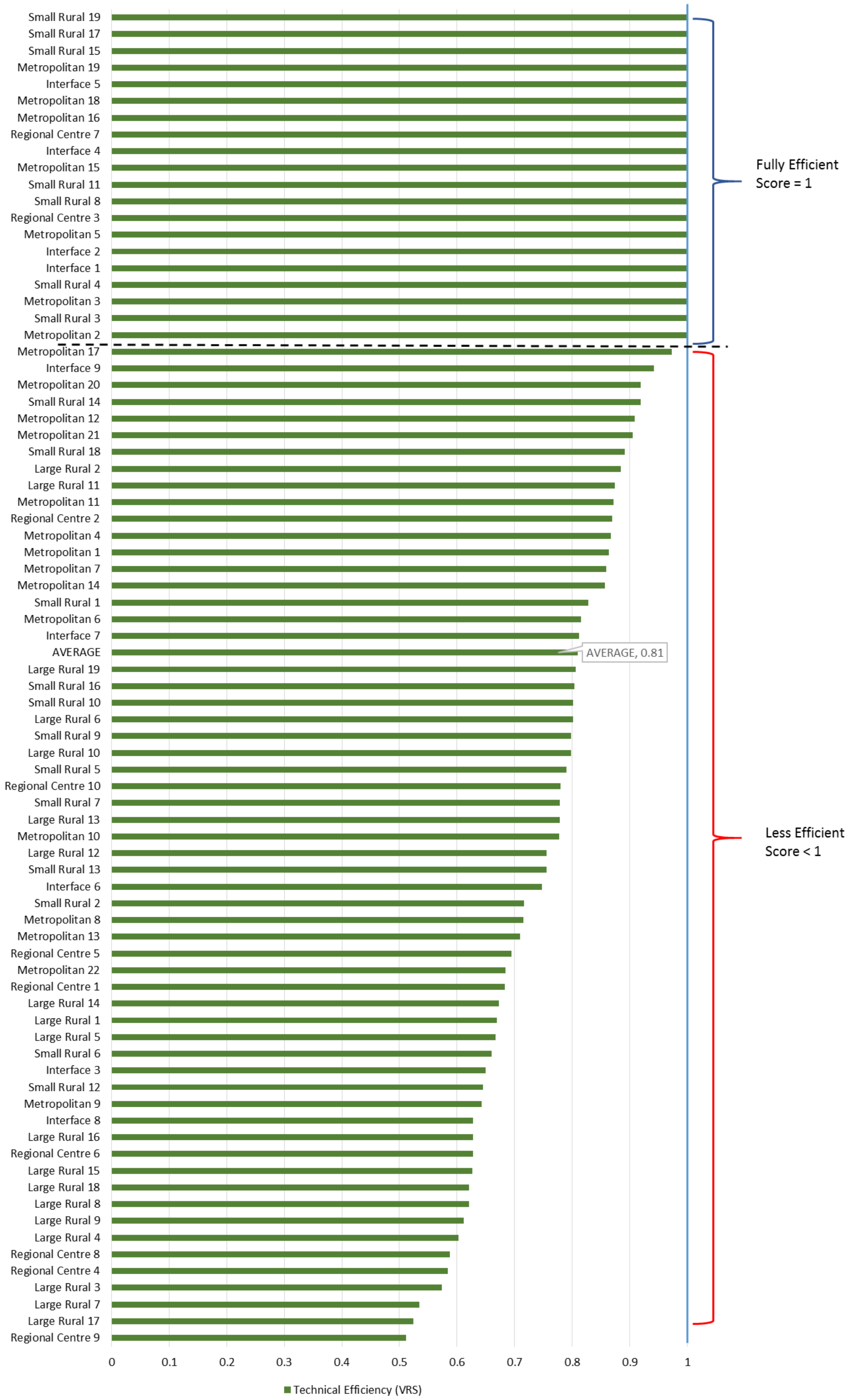
It should be noted that under different model specifications (in term of input and output specifications) and in different years, the results of the different local governments may be different to both in terms of the number of local governments that are fully efficient, as well as the order in which they fall, as displayed in Figure 1-2.

Throughout this report references are made to ‘single group’ and ‘multiple group’ analysis. Single group refers to the assessment of all 79 local councils as one group. The consideration of councils as one group implies that they all have similar attributes, i.e. geographic, financial and other. In contrast, ‘multiple group analysis’ assumes that there are differences between councils which should be accounted for. As such, to facilitate the multiple group analysis each of the 79 Victorian local governments were categorised according to the following groups:

- Interface
- Large Rural
- Metropolitan
- Regional Centre
- Small Rural

The report compares the results of the single and multiple group analysis.

Figure 1-2 - DEA (VRS) Technical Efficiencies for Model 1 (Single Group Analysis) in 2015-16



Efficiency Factor (X-factor) results

According to the Environment and Planning Committee's Third Report into Rate Capping,[7] the Commission has in the past recommended that efficiency rate caps should be set using a weighted combination of the Consumer Price Index (CPI) and the Wage Price Index (WPI) minus an efficiency factor (also known as an X-factor). The utility of an efficiency factor is that it can give a tangible goal which local governments can aim for in order to improve their efficiency. As hypothetical example, if an efficiency factor is computed for a 6% increase in efficiency over 5 years and the result is, for example, 0.04%, this would mean that in order for local governments to increase their efficiency by 6% over 5 years, they would need to decrease their inputs by 0.04% each year. Setting an efficiency factor gives local governments a clear goal as to how to improve their efficiency.

An X-factor is typically computed with reference to the existing and historic levels of local government productivity. Formally, the efficiency factor is computed as follows:

$$\boldsymbol{TFPC} + ((\mathbf{1} + \boldsymbol{p}(\mathbf{1} - \boldsymbol{TE}))^{\mathbf{1}/\boldsymbol{t}} - \mathbf{1}) \times \mathbf{100} \qquad (1.1)$$

where:

- TE is the Technical Efficiency.
- TFPC is the average annual change in Total Factor Productivity.
- This efficiency factor represents the number it would take inefficient local governments to reach an increase in efficiency of 100×*p*% over *t* years.
- The Commission may wish to have a greater or lower increase in efficiency over this time OR a shorter or longer time frame for the increase in efficiencies to be realised.

There are two methods of setting the variable TFPC. We denote them as Method 1 and Method 2. Method 1 is the method whereby the Commission sets a minimum increase in efficiency that it considers appropriate for all local governments. For the purposes of this analysis, the Method 1 TFPC was set at 0.05%.

The second method, Method 2, sets the TFPC to be equal to the average change in the Malmquist Index (the computation of which is described in Section 4.4). This method links the TFPC to the performance of local governments over a specified time period (financial years 2010-11 to 2015-16) based on their recent historic and current efficiencies.

In our analysis, three scenarios were considered, i.e. low, medium and high.[8] The low scenario assumes a 2.5% increase in efficiency (i.e. *p* in equation (1.1) is 0.025) over 5 years (i.e. *t* in equation (1.1) is 5). The medium scenario assumes a 5% increase in efficiency (i.e. *p* in equation (1.1) is 0.05) over 5 years. The high scenario assumes a 7.5% increase in efficiency (i.e. *p* in equation (1.1) is 0.075) over 5 years.

Table 1-4 presents the resultant X-factors computed via Method 1 and the methodology outlined in Section 4.5

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[7] Parliament of Victoria, Legislative Council Environment and Planning Committee (2016), *Third report into rate capping policy*, Victorian Government Printer, Melbourne.

[8] Each scenario proposes a different efficiency increase over time for the local governments as a whole. This in turn affects the value of the final efficiency factor

Table 1-2 - Efficiency Factor (X-factor) Results using Method 1 for Single Group Analysis

X-factor						
	Low 2.5% efficiency increase		Medium 5% efficiency increase		High 7.5% efficiency increase	
Model	DEA (CRS)	DEA (VRS)	DEA (CRS)	DEA (VRS)	DEA (CRS)	DEA (VRS)
1	0.18	0.15	0.31	0.24	0.44	0.33
2	0.19	0.15	0.33	0.25	0.47	0.35
3	0.17	0.13	0.29	0.22	0.40	0.30
4	0.18	0.14	0.32	0.24	0.45	0.33
5	0.17	0.14	0.29	0.23	0.41	0.32

The X-factor shows the percentage reduction in inputs per year that local governments would have to achieve to attain the specified efficiency gains according to the scenario (i.e. low, medium or high). For example, for Model 1 in the low scenario under the DEA (VRS) methodology, the X-factor is 0.15%. This translates to local governments being required to reduce costs by 0.15% per year to attain the 2.5% increase in efficiency over 5 years.

The results for the low scenario show X-factors ranging from 0.13% to 0.19%. X-factors tended to be higher for the DEA (CRS) technique than the DEA (VRS) technique.

The results for the medium scenario show X-factors ranging from 0.22% to 0.33%. This is higher than the low scenario results and is due to the fact that this scenario assumes a higher increase in efficiencies over the same time period than the low scenario.

The results for the high scenario show X-factors ranging from 0.30% to 0.47%. Again, this increase is due to the fact that this scenario assumes an even higher increase in efficiencies over the same time period as the other two scenarios.

Table 1-5 presents the resultant X-factors computed via Method 2 by the methodology outlined in Section 4.5.

Table 1-3 - Efficiency Factor (X-factor) Results using Method 2 for Single Group Analysis

X-factor						
	Low 2.5% efficiency increase		Medium 5% efficiency increase		High 7.5% efficiency increase	
Model	DEA (CRS)	DEA (VRS)	DEA (CRS)	DEA (VRS)	DEA (CRS)	DEA (VRS)
1	0.13	0.10	0.26	0.19	0.39	0.28
2	0.14	0.10	0.28	0.20	0.42	0.30
3	0.12	0.08	0.24	0.17	0.35	0.25
4	0.13	0.09	0.27	0.19	0.40	0.28
5	0.12	0.09	0.24	0.18	0.36	0.27

The results for the low scenario show X-factors ranging from 0.08% to 0.14%, depending on the technique used to estimate efficiency.

The results for the medium scenario show X-factors ranging from 0.17% to 0.28%. This is higher than the low scenario results and is due to the fact that this scenario assumes a higher increase in efficiencies over the same time period than the low scenario.

The results for the high scenario show X-factors ranging from 0.25% to 0.42%. Again, this increase is due to the fact that this scenario assumes an even higher increase in efficiencies over the same time period as the other two scenarios.

As additional analysis, local governments were grouped according to similar features in terms of their location in Victoria (e.g. Metropolitan local governments were grouped together, as were Small Rural local governments etc. – see Appendix A for a full list). The groupings and the number of local governments in each group are given in Table 1-6

Table 1-4 - Local Government Groupings

Group No.	Definition	No. Local Governments
1	Interface	9
2	Large Rural	19
3	Metropolitan	22
4	Regional Centre	10
5	Small Rural	19

Table 1-7 summarises the X-factors computed for multiple groups via Method 1.

Table 1-5 - Efficiency Factor (X-factor) Results using Method 1 for Multiple Group Analysis

X-factor						
	Low 2.5% efficiency increase		Medium 5% efficiency increase		High 7.5% efficiency increase	
Model	DEA (CRS)	DEA (VRS)	DEA (CRS)	DEA (VRS)	DEA (CRS)	DEA (VRS)
1	0.10	0.08	0.16	0.11	0.21	0.14
2	0.11	0.08	0.17	0.12	0.23	0.15
3	0.09	0.07	0.13	0.09	0.17	0.11
4	0.09	0.07	0.13	0.09	0.17	0.12
5	0.09	0.07	0.13	0.09	0.17	0.11

It should be noted that for the multiple group analysis, the X-factor for each individual local government was computed. This was done based on the technical efficiencies computed by grouping the local governments according to the groupings specified in Table 1-6. This means that the efficiencies were calculated only by reference to other local governments within each individual group. The resultant X-factors in Table 1-7 were then computed by averaging all the individual X-factors. The average X-factors were computed across all 79 local government.

The resultant X-factors are lower than the results for the single group analysis. This is owing to the fact that local governments are only compared to other similar local governments. In addition, it is important to note that DEA is a relative, not an absolute method of scoring efficiencies. This means that although a certain group of local governments may have a lower efficiency score as a result of being compared with all other local governments, their efficiencies may be higher when compared only with local governments that have similar attributes. For example, a rural local government may have a lower efficiency score as a result of being compared with metropolitan local governments, but have a higher score when compared only with other rural local governments.

According to Table 1-7, the X-factors associated with the low scenario range between 0.07% and 0.11%. X-factors computed under the DEA (VRS) framework tend to be lower than those under the DEA (CRS) framework. In regards to the medium scenario, the computed X-factors range between 0.09% and 0.17%. For the high scenario, X-factors ranged from 0.11% to 0.23%.

Table 1-8 summarises the X-factors computed for multiple groups via Method 2.

Table 1-6 - Efficiency Factor (X-factor) Results using Method 2 for Multiple Group Analysis

X-factor						
	Low 2.5% efficiency increase		Medium 5% efficiency increase		High 7.5% efficiency increase	
Model	DEA (CRS)	DEA (VRS)	DEA (CRS)	DEA (VRS)	DEA (CRS)	DEA (VRS)
1	0.05	0.03	0.11	0.06	0.16	0.09
2	0.06	0.03	0.12	0.07	0.18	0.10
3	0.04	0.02	0.08	0.04	0.12	0.06
4	0.04	0.02	0.08	0.04	0.12	0.07
5	0.04	0.02	0.08	0.04	0.12	0.06

According to Table 1-8, in regards to the low scenario, the X-factors range between 0.02% and 0.06%. X-factors computed under the DEA (VRS) framework tended to be lower than those under the DEA (CRS) framework. For medium scenario, the computed X-factors range between 0.04% to 0.12%. For the high scenario, X-factors range between 0.06% to 0.18%.

1.7 Conclusions & Recommendations

The following conclusions are made by PAG:

- The models considered for the efficiency computations are robust in terms of encompassing a broad range of inputs and outputs which are common to all local governments.
- DEA was utilised to compute local government efficiency and resultant efficiency factors. Of the DEA techniques utilised, the more robust method of estimating the efficiencies is the DEA with variable returns to scale.
  - This is due to its more realistic assumptions regarding the scale efficiency of local governments. If the Commission chooses to use a DEA framework for the computation of the efficiency factor, PAG recommends using the DEA (VRS) framework.
- On the basis of the literature review, the specification of inputs and outputs of Model 1 is considered to be preferred as it comprehensively and succinctly covers all the necessary inputs and outputs pertinent to local government operations.
- Analysis was conducted by considering all local governments as a single group and by considering local governments in relevant sub groups. The Commission has the choice to utilise results from either form of analysis. The analysis utilising sub groups looked at local governments in groups in which local governments were of a similar nature
- The calculation of the X-factor scores was robust to a range of alternative specifications. The Commission can choose between a low range of efficiency increase (2.5% increase over 5 years), a medium range of efficiency increase (5% increase over 5 years), and a high range of efficiency increase (7.5% increase over 5 years).
- The Commission has a choice whether to use Method 1 or Method 2 for setting the TFPC in calculating the efficiency factor.

2 Introduction

2.1 Background and objective

In February 2015, the Commission was given terms of reference by the Ministers for Finance and Local Government in which it was asked to design a framework that would meet the Government's commitment to cap annual local government rate increases as well as to develop a workable process to assess any proposals by local governments for above cap increases.

In July 2015 the Commission, outlined its design for a new framework that would meet the Government's commitment to cap annual local government rate increases, as well as to develop a workable process to assess any proposals by local governments for above cap increases. After receiving extensive feedback from the local government sector, ratepayers and other stakeholders, a final report was released by the Commission in October 2015. Shortly after, the Government released its response to the recommendations made in the final report and subsequently passed legislation in December which gave effect to the rate capping, variation mechanism, and monitoring and reporting process, known as the Fair Go Rates System.

The objective of this analysis is to assess the productivity and efficiency of local governments, and then use the efficiency scores to compute efficiency factors for the Commission to consider. The scope of the engagement has two distinct stages described below.

Stage 1 includes the following:

- A review of data sets provided by the Commission and independently sourced to determine the suitability of the data for analysis.
- Work with Commission staff to compile necessary data.

It is also required that preliminary work be undertaken to calculate productivity levels in the local government sector. This includes:

- Developing the data requirements to calculate productivity trends using a total factor productivity (TFP) approach. This involves selecting appropriate data from the Victorian Grants Commission (VGC) data as well as ensuring the consistency and veracity of the data reported.
- Calculating indicative productivity levels using a suitable TFP approach. Productivity may be measured across the whole sector or by meaningful sub group[9].
- Clearly explain the reasons driving productivity trends in the sector – decompose productivity into its drivers.

2.3 Approach

An analysis into the Victorian local government sector should acknowledge that each local government may have different characteristics when compared with other local governments. Local governments provide a wide variety of services to their municipalities including, for example, public health, traffic, parking and animal management. The scale and scope of activities undertaken by individual local governments may vary depending on the size and nature of their municipality.

[9] Subgroups of Victorian local governments are defined as: Interface, Large Rural, Metropolitan, Small Rural and Regional Centre.

As such, as part of this analysis, local governments will be grouped according to predefined groupings of local governments which all have similar characteristics. The 79 Victorian local governments will each be categorised in one of the following groups:

- Interface
- Large Rural
- Metropolitan
- Regional Centre
- Small Rural

Our approach can be summarised as follows.

Stage 1 includes the following:

- Compile necessary datasets including the aforementioned VGC as well as publicly available data regarding Victorian local governments.
- Review the data sets to determine what information is suitable to enable meaningful comparisons to be made among local governments.

It is also required that preliminary work be undertaken to calculate productivity levels in the local government sector. This includes:

- Developing the data requirements to calculate productivity trends using a total factor productivity (TFP) approach. This involves selecting appropriate data from the VGC data as well as ensuring the consistency and veracity of the data reported.
- Calculating indicative productivity levels using suitable TFP approaches. Productivity may be measured across the whole sector or by meaningful sub group.[6]

Stage 2 includes the following:

- Refining the calculations undertaken in stage 1 to incorporate any new assumptions or updated information in light of consultation with the sector.
- Isolate and quantify the factors that may influence changes in productivity trends in the sector..

2.4 Structure of the Report

This report is structured as follows:

- Section 3 provides a description of our methodology;
- Section 4 provides a literature review detailing the aforementioned approaches and technical details of the methods used for computing the technical efficiencies and efficiency factors;
- Section 5 presents the results;
- Section 6 outlines the impact of sensitivity analysis; and
- Section 7 presents conclusions and recommendations.

Throughout the report we also provide detailed mathematical algorithms, the objective of which is to facilitate replication of PAG's results by any independent third party.

3 Data capture and review

3.1 Introduction

The following data was provided by the Commission for the financial years 2010/11 – 2015/16:

1. ALG1 Road Length and Expenditure;
2. VCG1 Expenditure and Revenue;
3. ABS1 Capital Outlays and Sales;
4. ABS2 Balance Sheets;
5. VLGAS Region by Council;
6. LGV1 Council Employment; and
7. VCG2 Valuations and Rates.

In addition, data relating to the Local Government Performance Reporting Framework for 2014/15 – 2015/16 as well as the VCG Questionnaire Manuals for 2010/11 – 2015/16 were also provided.

Data was also obtained from the Australian Bureau of Statistics (ABS). In particular, statistics for local government areas regarding the number of households and businesses. Where the data was not reported every year, the data was interpolated and extrapolated where necessary to construct a complete dataset for all the necessary years under consideration in this report.

A comprehensive table listing all data is contained within Appendix B.

3.2 Availability of data to facilitate TFP analysis

The data provided by the Commission was examined against the data input and output requirements of TFP with a specific focus on DEA methods. Where it was found that the VGC data did not satisfy the requirements, we examined whether data existed in the public domain that could be used to facilitate robust TFP analysis. Table 3-1 and 3-2 below summarise the required inputs and outputs of DEA and the source from which they were obtained.

Table 3-1 – DEA Inputs

Inputs	Definition	Source
Staff (FTE)	Number of staff in Full-Time Equivalent (FTE) units	LGV1 (Heading 2399)
Staff ($)	Total staffing cost	VGC1 (Total Expenses 01999: Employee Benefits)
Capital ($)	Material and other expenses from Income Statement	ABS1 (Total Outlays 02999: TOTAL)
Operational Expenses ($)	Expenditure (not including depreciation and amortisation)	VGC1 (Total Expenses 01999 – Depreciation and Amortisation)
Depreciation ($)	Depreciation and amortisation	VGC1 (Total Expenses 01999: Depreciation & Amortisation)

Table 3-2 – DEA Outputs

Outputs	Definition	Source
Businesses	Number of Businesses in the municipality	Australian Bureau of Statistics: 1379.0.55.001 - National Regional Profile, 2010-14
Households	Number of Households in the municipality	Australian Bureau of Statistics: 1379.0.55.001 - National Regional Profile, 2010-14
Roads	Total length of roads (in kms) maintained by the local government	ALG1 (Length of Roads 2100 Total (kms))
Waste Collected	Amount of waste collected in tonnes	VLGAS (Tonnes Collected)

Our findings in relation to the availability of the data to inform these outputs has been discussed in Section 5 of this Report.

In the following report, the number of households and number of businesses, as well as road length are used as outputs. This is owing to the fact that Victorian local governments primarily provide services to households and businesses, as well as being responsible for the maintenance of roads. This is has been noted in studies such as Drew and Dollery (2014). As noted, Australian local governments in general provide services to property. Drew and Dollery (2014) note that some functions not traditionally involved in the domain of local government have become a part of local government function. However, the study states that 'these emerging services…are still relatively insignificant compared with the traditional services to property remit of Australian local governments'. If services to people were included in the analysis, a better proxy in terms of an output variable would be population. However, Drew and Dollery (2014) find that the number of households and businesses is in fact more representative of the true output of Victorian local governments.

4 Method employed to calculated efficiencies using a direct approach

4.1 Introduction

In this section, we calculate total factor productivity (TFP) trends and undertake a sensitivity analysis to ensure that our estimates are robust to alternative assumptions.

4.2 Calculation of trends using TFP

As stated throughout this report, to calculate TFP, Data Envelopment Analysis (DEA) was employed. This method is discussed below.

Data Envelopment Analysis

DEA was first posited in Farrell (1957) and was formulated as a means to assess the efficiency of entities across a broad range of factors. Previous attempts at measuring efficiency relied on techniques such as the 'average productivity of labour' which employ only part of the available information pertaining to an entity or organisation. By contrast, DEA considers a broad range of inputs and outputs, not only traditional variables such as, labour. Another popular method, prior to DEA, was the so-called 'indices of efficiency' which added all the inputs together. The drawback with this approach is that different inputs may have different scales. This means that inputs on smaller scales would not carry the same weight as inputs on larger scales. DEA addresses this issue by considering each input on a separate scale.

DEA is considered a standard approach for estimating Australian local government efficiency scores. It has been used in a range of academic papers and government reports including but not limited to:

- Worthington and Dollery (2001): NSW municipal waste management.
- Worthington and Dollery (2000): Efficiency of NSW local governments.
- Worthington (2000): Cost efficiency in Australian local government.
- Drew, Kortt and Dollery (2015): NSW local government efficiency.
- Woodbury and Dollery (2004): NSW municipal water services.
- Gregan and Bruce (1997): Report into the technical efficiency of hospitals in Victoria.

DEA has also been used for efficiency analysis in international government contexts. See, for example:

- Afonso, Schuknecht and Tanzi (2006): European Central Bank public sector efficiency analysis.
- Afonso and Fernandes (2005): Efficiency of Portuguese municipalities.

DEA has also been applied to various non-government contexts in order to facilitate the estimation of efficiency of various entities. For example:

- Hjalmarsson, Kumbhakar and Heshmati (1996): A comparison of DEA and stochastic frontier techniques for Colombian cement plants.
- Sharma, Leung and Zaleski (1996): An efficiency analysis of the swine industry in Hawaii.
- Balcombe, Fraser and Kim (2005): an analysis of the efficiency of Australian dairy farms.

The lists presented above are by no means exhaustive, but should demonstrate that DEA is a well-accepted methodology for efficiency analysis both in the Australian local government context and other contexts.

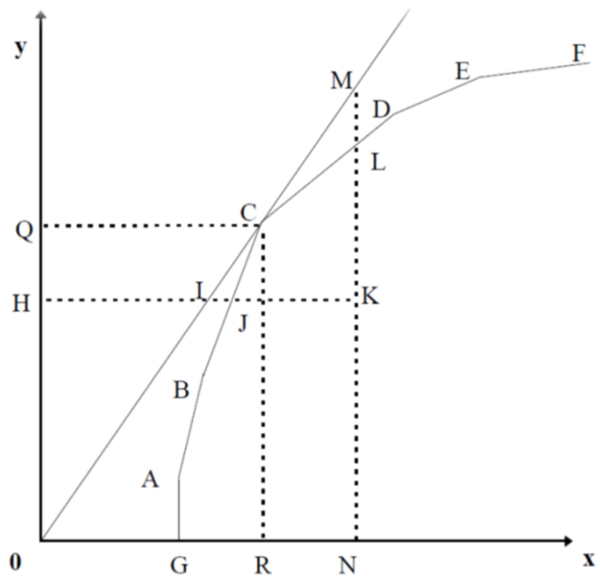
DEA is a method of computing efficiency and productivity of an entity. Efficiency can be defined as the degree to which the observed use of resources to produce outputs matches the optimal use of resources to produce outputs. Productivity can be thought of as the measure of output produced from the use of a given quantity of inputs. *Total factor productivity (TFP)* is productivity which encapsulates all inputs and outputs. TFP will be used to assess the change in productivity of local governments from year to year.

DEA is a linear programming methodology which constructs a frontier, which indicates full efficiency, and then computes the efficiency as the distance an individual local government is from that frontier. CRS (constant returns to scale) and VRS (variable returns to scale) DEA were used to compute technical and scale efficiencies. Constant returns to scale assumes that an increase or decrease in inputs results in the same sized increase or decrease in outputs. This is possible if the entities in question are all scale efficient. Variable returns to scale does not assume that all entities are scale efficient. Under the variable returns to scale framework, it is assumed that an increase or decrease in inputs can also lead to a greater or lesser increase or decrease in outputs. These methods are well accepted approaches within the DEA framework (see, for example, Fare, Grosskopf and Lovell (1994)).

A salient feature of DEA is that it is a relative technique. The frontier produced by the DEA is not that of a theoretically perfect local government. The technique uses the available local governments in order to assess which are the most efficient, relative to the other local governments. The implication of this is that even if a local government is judged by the DEA methodology to be fully efficient (or 'on the frontier'), it is still possible for the local government to become more efficient and shift the frontier further forward. As such, any resultant X-factor does not necessarily penalise more efficient local governments, only spur them to push the frontier further forward.

An example of the DEA method is given in Figure 4-1 below for an example single-input (x) and single-output (y) scenario.

Figure 4-1 - A hypothetical DEA frontier (source: Worthington and Dollery (2001))



The frontier surfaces may be either linear, i.e. a straight line, as in the CRS case, or convex as with VRS case. The CRS frontier in Figure 4-1 is the straight line 0ICM. The VRS frontier is the line GABCDEF. An example of an inefficient local government is indicated by the point K. The efficiency of a local government represented by point K is given by the distance between the frontier and point K. Specifically, the CRS technical efficiency is measured by $\frac{HI}{HK}$ and the VRS technical efficiency is measure by $\frac{HJ}{HK}$. For a local government on both the CRS and VRS frontiers, such as that at point C, the technical efficiency would be 1 as the efficiency in both cases would be $\frac{QC}{QC}$.

The VRS frontier is built by the local governments which bound all the other local governments. For example, the points A, B, C, D, E and F could all be considered local governments in this hypothetical scenario. These points bound other points representing other local governments such as K. This is why DEA can be considered to give relative efficiencies. There is no assumption of some sort of perfect efficiency. Full efficiency is determined by where all the local governments are relative to each other. The CRS efficiency is the straight line 0ICM. This frontier is computed so that it is intersects with at least one local government which, in relative terms, is representative of the most efficient local government of those in the data.

On a more technical level, DEA (CRS) efficiencies are computed by solving the following linear programs for each local government (in the case of this report, it is N=79 local governments):

$$\min \boldsymbol{\theta_n}$$

$$\text{subject to}$$

$$\sum_{j=1}^{N} w_j y_{ij} - y_{in} \geq 0 \qquad i = 1, \dots, I$$

$$\sum_{j=1}^{N} w_j x_{kj} - \theta_n x_{kn} \leq 0 \qquad k = 1, \dots, K$$

$$w_j \geq 0 \qquad j = 1, \dots N$$

In the above linear program θ_n is the technical efficiency for the *n*-th local government, y_{ij} is the *i*-th output value for the *j*-th local government, x_{kj} is the *k*-th input for the *j*-th local government, and w_j represents the weights across all *n* local governments which are common across all 79 linear programs.

For DEA (VRS), the linear program is the same except the following additional constraint on the weights is added:

$$\sum_{j=1}^{N} w_j = 1$$

Generally speaking, DEA (VRS) is the preferred model. This is due to the fact that DEA under the VRS framework does not assume all local governments are scale efficient (see, for example, Banker, Charnes and Cooper (1984) and the Steering Committee for the Review of Commonwealth/State Service Provision Report (1997)[10]). DEA (CRS) assumes all local governments are scale efficient. Given the number of local governments and their differences, it would be unreasonable to assume that all local governments are scale efficient. To this end, it would be preferable to use DEA (VRS) technical efficiencies rather than DEA (CRS) technical efficiencies to compute the efficiency factors.

It should also be noted that in this report, the DEA used is that of an input oriented DEA. This assumes that the local government has a large degree of control over its inputs and takes outputs to be exogenous. This assumption has a realistic basis in that local governments can control their spending (or inputs), but do not have such a great control over the number households and businesses in the municipality (or outputs). This is in line with research into the efficiency of local governments (see, for example, Worthington and Dollery (2001)).

4.3 Challenges of measuring productivity and efficiency

There are a number of factors which must be considered in measuring efficiency using DEA. These range from having reliable data sets and which sources of data should be used to issues of whether certain aspects are within the control of local governments.

Sourcing a suitable data set which succinctly and comprehensively covers local government inputs over a reasonable period of time is a necessary step. Ideally, input and output data should cover the broadest possible set of functions of a local government which is common to all local governments. It is possible to have reference to the literature to ascertain what functions are deemed to cover such requirements (see, for example, Drew, Kortt and Dollery (2015)). In addition, consulting with the sector through stakeholder meetings as well as with the Commission to ascertain what the general functioning of local governments tends to be is a useful manner in which the best possible set of inputs and outputs can be compiled.

The not for profit nature of the local government sector adds certain challenges to utilising DEA. The usual approach to evaluate production efficiency uses both input and output quantitative indicators and information about their unit prices. However, one of the basic problems in evaluating public sector activities through this approach is that market prices for outputs are commonly unavailable (see, for example, Afonso and Fernandes (2008)). In order to circumvent this issue, methods utilising proxies for the outputs have been used in a number of cases. In Australia, local governments are primarily considered to have a services to property mandate (Drew and Dollery (2014)). In this regard, it is possible to use the number of households and business, as well as the length of roads serviced as proxies for outputs as has been done in a number of instances (Drew and Dollery (2014) or Drew, Kortt and Dollery (2015)).

Limitation of the Analytical Framework

There are also a number of possible sources of limitations to this analytic framework. Firstly, it should be emphasised that DEA is a relative method of assessing an entity's efficiency. This means that the entities being assessed are not compared to a hypothetical perfect entity, but to each other. The entities that are determined to be the most efficient, are stipulated as such owing to their performance *relative* to the other entities.

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[10] Available at http://www.pc.gov.au/research/supporting/data-envelopment-analysis

There are also limitations on the analysis from the perspective of the data. First of all, there may be unmeasured quantities of input which are not, and cannot, be accounted for. An example of this would the use of volunteers by local governments. Their input would not be accounted for in, for example, staff costs. Secondly, there may be issues with the veracity of the data given this report utilises unaudited Victorian Grants Commission data. However, every effort has been made to consult with the Commission to assess any data that may appear to be anomalous. Finally, there may be a delay between when an input appears to be recorded (such as a capital outlay), and when that input was actually utilised. By assessing local government performance over a number of years via the use of Total Factor Productivity, this is issue should be ameliorated to a certain degree.

4.4 Decomposing TFP into its drivers

Malmquist DEA was used to decompose TFP change into the following components: (i) technical efficiency change and (ii) technological change.

Typically, the Malmquist index allows for the quantification of change between economies. In this report, it is used to account for the change of efficiency indicators between two different years. Technical efficiency change indicates the change in efficiency from one year to the next. This is can be described as the improvement in productivity through further adoption of existing technologies. In other words, it is representative of local governments moving closer to (or further from) the frontier. If the efficiency of a local government has increased from one year to the next, the technical efficiency change will be greater than one. If efficiency has decreased from one year to the next, the technical efficiency change will be less than one. No change in technical efficiency is indicated by a value of one. This change is determined by the production frontier in the previous year and in the subsequent year (i.e. two different production frontiers are used in the calculation of the technical efficiency change).

Technological change compares the production technology of, in this report, two consecutive years. Simply put, it compares the ability of a local government in one year to efficiently transform inputs into outputs with the same local government's ability in another year to efficiently transform inputs into outputs. This represents the expansion or contraction of the production frontier – that is, the local governments on the frontier increasing or decreasing their efficiency. If the technological change is greater than one, then the local government in the subsequent year had a superior ability to efficiently transform inputs into outputs. If the technological change is less than one, then the local government in the previous year had a superior ability to efficiently transform inputs into outputs (see, for example, Worthington (1999)). The technological change is essentially a ratio of how well a local government performs in both years with inputs from a previous year and how well a local government performs in both years with inputs from a subsequent year.

Malmquist total factor productivity has been used in a variety of settings in order to quantify the productivity change over time. Some examples include:

- Worthington (1999): Analysing the productivity change of financial services.
- Abbott (2006): Analysing the productivity change of the Australian electricity supply industry.
- Sung (2007): Efficiency and productivity change of Korean local governments.
- Avkiran (2000): Productivity of Australian banks under deregulation.

The following outlines the mathematics regarding technological change and technical efficiency change for DEA Malmquist indexes:

1. **Technological change** is the expansion or contraction of efficiency due to technological changes (i.e. the adoption of new technologies resulting in the expansion or contraction of the production frontier). In essence, this variable indicates how innovative a local government has been with their technology.
    a. DEA: in mathematical terms, the technological change is given by:

$$TC(x,y) \approx \left[\frac{D_{t-1}(x_t,y_t)}{D_{t-1}(x_{t-1},y_{t-1})} \times \frac{D_t(x_t,y_t)}{D_t(x_{t-1},y_{t-1})}\right]^{0.5}$$

    where D_t is the distance function for the frontier at time t, x represents the inputs, y represents the outputs, and t is the time period.[11]

2. **Technical efficiency change** is the change in being able to more efficiently produce outputs y using inputs x (i.e. the movement of local governments closer to or further from the existing frontier).
    a. DEA: The change from period to period indicates whether the efficiency is increasing or decreasing. In mathematical terms, we define the change in output technical efficiency to be:

$$TEC(x_t,y_t) = \frac{D_t(x_t,y_t)}{D_{t-1}(x_{t-1},y_{t-1})}$$

It should be noted that Malmquist DEA utilises both the CRS and VRS frontiers in order to calculate the Malmquist index. Technical efficiency change can be thought of the movement of local governments closer to or further from the existing frontier. Technological change essentially is an indicator of the contraction or expansion of the production frontier. An expanding production frontier indicates that local governments are being innovative and moving the production frontier forward. A contracting production frontier means the frontier is moving backwards.

The Malmquist index is a measure of whether a local government, or the sector as a whole (if the Malmquist indexes for the entire sector and all years are averaged). The Malmquist index is the result of multiplying the technical efficiency change and the technological change. For example if the technical efficiency change is 0.9984 and the technological change is 1.0037 then the Malmquist index is approximately 0.9984×1.0037≈1.002.

The Malmquist index can be used to compute the TFPC. First the Malmquist index over all periods is averaged. To give the average Malmquist index. If the result is, for example, 1.02, this indicates that on average, over the entire time period, this hypothetical local government has increased efficiency by 2% (i.e. (1.02-1)×100). Hence the TFPC is 2%. If another hypothetical local government has a mean Malmquist index of 0.97, this local government has on average, decreased efficiency by -3% (i.e. (0.97-1)×100). In this case, the TFPC would be -3%. However, as will be discussed in Section 4.5, TFPC is bounded below by zero, meaning that if the lowest value the TFPC can take is zero. This is to ensure that efficiency factors are never negative.

[11] Digression, DEA utilises the distance function defined as:
$D_t(x_t,y_t) := inf\left\{\delta | \delta > 0, \frac{y_t}{\delta} \in P_t(x_t)\right\}$ where x represents the inputs, y represents the outputs and
$P_t(x_t) := \{y_t | D_t(x_t,y_t) = 1\}$

4.5 Computation of the X-factor

The utility of an efficiency factor is that it can give a tangible goal which local governments can aim for in order to improve their efficiency. For example if an efficiency factor is computed for a 5% increase in efficiency over 5 years and the results is, for example, 0.05%, this would mean that in order for local governments to increase their efficiency, they would need to decrease their inputs by 0.05% each year. Setting an efficiency factor gives local governments a clear goal as to how to improve their efficiency.

The efficiency factor is computed in the following manner:

$$\boldsymbol{TFPC} + ((\mathbf{1} + \boldsymbol{p}(\mathbf{1} - \boldsymbol{TE}))^{\mathbf{1}/\boldsymbol{t}} - \mathbf{1}) \times \mathbf{100} \qquad (4.1)$$

where:

- TE is the Technical Efficiency.
- TFPC is the average annual change in Total Factor Productivity.
- This efficiency factor represents the number it would take inefficient local governments to reach an increase in efficiency of 100×*p*% over *t* years.
- The Commission may wish to have a greater or lower increase in efficiency over this time OR a shorter or longer time frame for the efficiencies to be realised.

The following is a worked example of a hypothetical calculation of an X-factor. First the values of *p* and *t* are set. For example, it may be regarded that local governments should make a 50% increase in efficiency. This means that *p* is set at 0.5. This increase in efficiency should occur over 5 years. This means that *t* is set at 5. TFPC can be set to be the geometric mean of the increase or decrease in the Malmquist index over the entire period of data considered. In current context, data is available from 2010-11 to 2015-16. The geometric mean of the increase or decrease in the Malmquist index of all local governments is defined as the TFPC (the average change in total factor productivity). In other words

$$TFPC = (Malmquist\ Index\ Average - 1) \times 100$$

In our example, the Malmquist index might be 1.01. Therefore TFPC would be 1 (indicating an average 1% increase from year to year as (1.01-1)×100 is 1%). The mean technical efficiency under a certain framework (either DEA (CRS) or DEA (VRS)) is the used as TE (the technical efficiency). This may be computed to be 0.9, for instance. Utilising all these numbers gives the following computations through the use of equation (4.1):

$$\begin{aligned} &TFPC + ((1 + p(1 - TE))^{1/t} - 1) \times 100 \\ &= 1 + ((1 + 0.5(1 - 0.9))^{1/5} - 1) \times 100 \\ &= 1 + ((1 + 0.5 \times 0.1)^{1/5} - 1) \times 100 \\ &= 1 + (1.009806 - 1) \times 100 \\ &= 1 + 0.9806 \\ &= 1.9806 \end{aligned}$$

Meaning that the X-factor in our hypothetical example is 1.98% which equates to local governments having to decrease inputs by 1.98% each year in order to attain a 50% increase in efficiency over five years.

It should be noted that TFPC will be bounded at zero, meaning if the TFPC were to be calculated as negative (in other words, the average Malmquist index were less than 1), then TFPC would be set to zero.

Another example is if the Malmquist Index Average were 1.01 but the technical efficiency were determined to 0.8 instead, a 50% increase in efficiency over 5 years would mean an efficiency factor calculated as:

$$
\begin{aligned}
&TFPC + \left(\left(1 + p(1 - TE)\right)^{\frac{1}{t}} - 1\right) \times 100 \\
&= 1 + \left(\left(1 + 0.5(1 - 0.8)\right)^{\frac{1}{5}} - 1\right) \times 100 \\
&= 1 + (1.019245 - 1) \times 100 \\
&= 1 + 1.9245 \\
&= 2.9245
\end{aligned}
$$

As can be seen from the result, if the technical efficiency is lower, the resultant efficiency factor will be higher, as the there is a greater ability of the local government to improve its efficiency.

As a final example, we demonstrate the computation of the efficiency factor if the TFPC were to be negative. For example, if the Malmquist Index Average is equal to 0.966. Using the formula for the TFPC would result in

$$TFPC = (0.966 - 1) \times 100 = -3.4$$

Given the result is negative, the TFPC will be set to zero. If the technical efficiency were to be determined to be 0.9, and a 50% increase in efficiency over five years were set as the necessary increase in efficiency, the efficiency factor is computed as:

$$
\begin{aligned}
&TFPC + \left(\left(1 + p(1 - TE)\right)^{\frac{1}{t}} - 1\right) \times 100 \\
&= 0 + \left(\left(1 + 0.5(1 - 0.9)\right)^{\frac{1}{t}} - 1\right) \times 100 \\
&= (1.009806 - 1) \times 100 \\
&= 0.9806
\end{aligned}
$$

It is necessary to set the TFPC to zero if it is negative as not doing so may result in an efficiency factor which is negative. This would mean that there would be no impetus for efficiency gains. The calculation of the efficiency factor still results in a fair efficiency factor as it acknowledges that the efficiency factor should not be higher as historically local governments may have been decreasing in performance. In addition the current state of the efficiency of local governments is also still used in computation of the efficiency factor, ensuring that the current state of the local government sector is accounted for in the calculations.

4.6 Sensitivity analysis: Refinement of calculations to facilitate changes in assumptions

Scenario analysis can be added to the DEA technique. Namely, inputs can be varied to accommodate possible future scenarios. We accomplish this by modifying the inputs of the linear programming model used by the DEA. In the field of linear programming this is known as ‘modifying the right hand side’. In essence, the variables which make up the optimisation procedure of the linear programming which is used in DEA are changed in order to ascertain the effect on the final objective function (which is the efficiency estimate). From this, we can compute the updated efficiencies in the same manner as for the original scenario using the updated inputs which reflect the new scenario. By doing this, the effect on the estimates of efficiency for various scenarios of interest will be readily quantifiable. The procedure for computing the efficiencies from a scenario is precisely the same as computing the original efficiencies but with modified inputs to reflect a given scenario.

5 Results

5.1 Introduction

The final calculation of the X-factor is accomplished via the use of the efficiencies computed by the DEA models. A variety of input-output combinations were used in order to paint a broad picture of the performance of the Victorian Local Government sector. The input-output combinations that were used to obtain the results shown in this section are:

Table 5-1 - Modelling Framework Inputs and Outputs

Model	Inputs	Outputs
Model 1	Staff ($) + Capital ($)	H/holds + Businesses + Roads
Model 2	Staff (FTE) + Capital ($)	H/holds + Businesses + Roads
Model 3	Staff ($) + Capital ($)	H/holds + Businesses + Roads + Waste (Tonnes)
Model 4	Capital ($) + Operating Expenses (excluding Depreciation) ($)	H/holds + Businesses + Roads
Model 5	Operating Expenses (excluding Depreciation) ($) + Depreciation ($)	H/holds + Businesses + Roads

A robust model is one which encapsulates the broadest range of possible inputs which are common to all local governments and account for the full scale of local government operations, and covers the broadest range of possible outputs (in terms of services provided) which are common to all local governments. For example, staffing costs, whether in dollar terms or fulltime equivalent units (FTE), and capital outlays are common to all local governments and account for the majority of local government inputs. This model specification is covered by Models 1, 2 and 3. An alternative specification, which also covers a broad range of local government inputs, is the use of capital outlays and operating expenses (excluding depreciation) or operating expenses (excluding depreciation) and depreciation. Such specifications are used in Models 4 and 5.

Equally important is the broadest possible specification of outputs (in other words services to whom the services represented by the inputs were rendered). Services are primarily rendered to households and businesses. In addition, all local governments have the necessity of servicing roads in their local government area. To account for the services rendered to these entities, Models 1, 2, 4 and 5 were specified. On top of these specifications, it can be of value to specify a model which accounts for the amount of waste collected. This is a service common to all local governments. To this end, Model 3 was specified.

According to the academic literature relating to the analysis of local government efficiency, the specification of inputs and outputs as specified in Model 1, is considered the most comprehensive and succinct (see Drew, Kortt and Dollery (2015)). It is comprehensive because it covers all inputs and outputs considered relevant to local governments. Further, it does not double count certain aspects of local government inputs or outputs. For example, if population were included as an additional output in addition to the number of households, this could be considered double counting the ‘number of households’ output measure.

As outlined previously, Drew, Kortt and Dollery (2015) specify a number of additional reasons why Model 1 is the preferred model. Firstly, 'staffing costs' provide a more robust measure of the input that staff members have into a local government's operations compared with 'staff FTE' measure (as is used in Model 2). This is because not all staff are paid the same rate and salary - factors that are considered to reflect responsibility, experience and quality of work.

Furthermore, borrowing costs should be excluded as an input as these may act to artificially inflate the inputs rather than contribute to the outputs. The inclusion of borrowing costs may penalise those with debt as the borrowings may not directly map to use for outputs. In addition, the number of households and businesses is considered to be a more stable representation of outputs than population and should be used in preference to population as an output.

Finally, given the inconsistent treatment of depreciation among local governments, depreciation should be excluded as an input due to the fact that for different local governments the figures have different meanings depending on how the local government chose to report the figure. As such, the specification of Model 1 in terms of inputs and outputs is considered in the literature of Australian local government efficiency to be the preferred model specification.

In addition, compiling additional inputs or outputs may have a minimal or even negligible impact on the efficiency scores of local governments. This can be owing to the fact that the additional data only accounts for relatively small part of local government operations.

Furthermore, the inputs considered in the above model formulations cover a broad spectrum of local government operations. While costs of specific "services to people" may not be included separately, they are still included under headings such as Operating Expenses (excluding Depreciation) or Staff Costs.

To facilitate the DEA analyses, all Victorian local governments were considered as a single group.

However, an analysis into the Victorian local government sector should also acknowledge that each local government may have different characteristics when compared with other local governments. Local governments provide a wide variety of services to their municipalities including, for example, public health, traffic, parking and animal management. The scale and scope of activities undertaken by individual local governments may vary depending on the size and nature of their municipality.

Further analysis was undertaken with local governments grouped according to the geographic regions detailed in the table below.

Table 5-2 - Local Government Groupings

Group No.	Definition	No. Local Governments
1	Interface	9
2	Large Rural	19
3	Metropolitan	22
4	Regional Centre	10
5	Small Rural	19

A full listing of which group each local government belongs to can be found in Appendix A.

5.2 Results of DEA Model

This subsection details the results of the DEA analysis including both the CRS and VRS frameworks for the 2015-16 financial year.

5.2.1 Efficiency Calculation

5.2.1.1 Single Group Analysis

Efficiency Calculations

The aggregated statistics of the efficiencies computed for the local government areas as a single group for the models listed above are presented in Table 5-3 below.

It should be noted that the results presented in this section are averages of all 79 local governments and do not represent each local government's performance on an individual level.

Table 5-3 - DEA Mean Technical Efficiencies for Single Group Analysis 2015-16

Model	Mean Technical Efficiency		Standard Deviation of Technical Efficiency		On the frontier	
	CRS	VRS	CRS	VRS	CRS	VRS
1	0.74	0.81	0.16	0.15	9	20
2	0.71	0.79	0.17	0.16	6	17
3	0.76	0.83	0.16	0.15	11	23
4	0.73	0.81	0.16	0.15	6	18
5	0.76	0.82	0.15	0.14	6	15

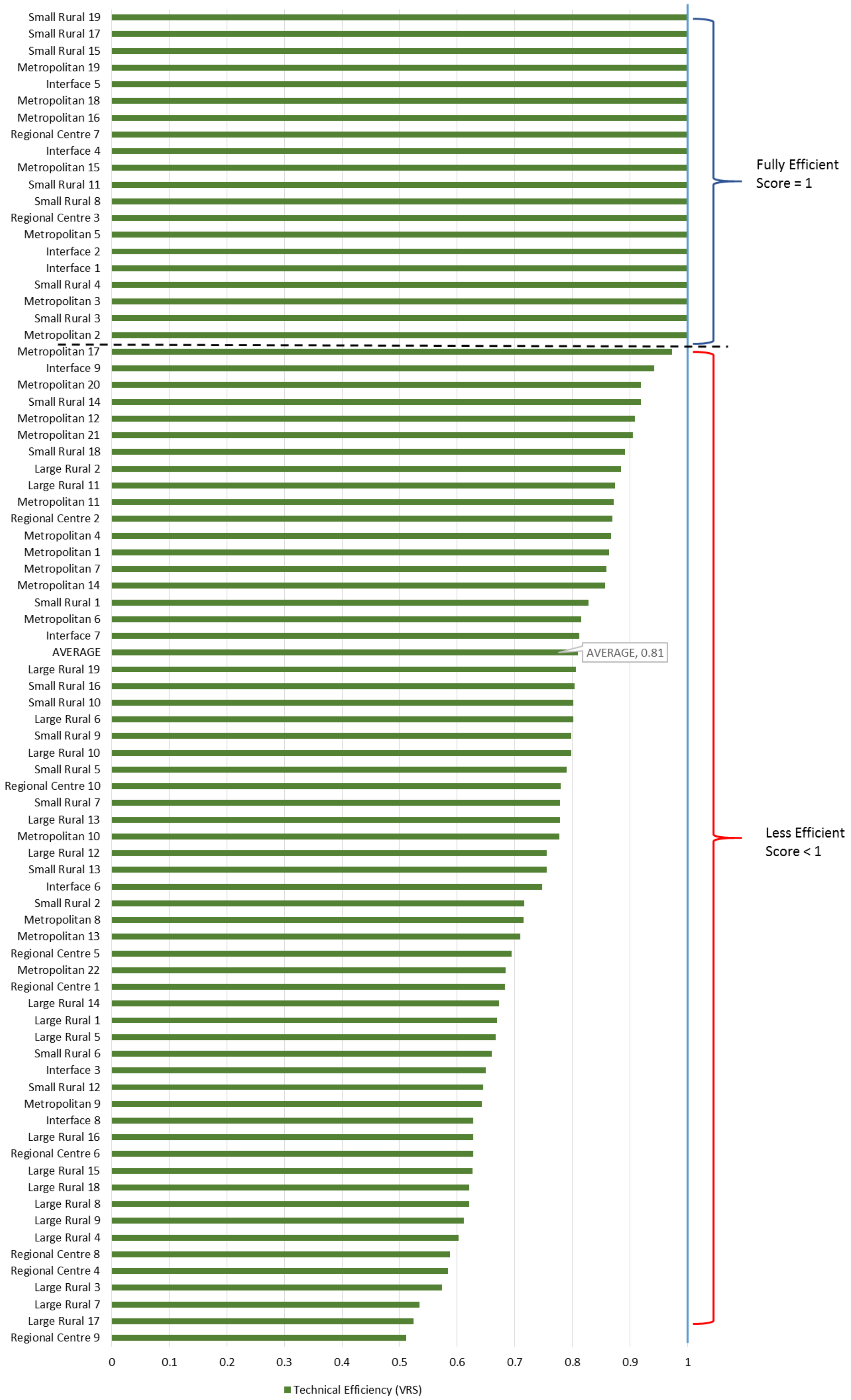
The mean technical efficiencies range from 71% to 83% depending on the model specification and whether CRS or VRS is used. Model 3 has the highest mean technical efficiency under the VRS framework at 83%. Model 2 has the lowest mean technical efficiency under the CRS framework.

As can be seen from the above results, the variability in efficiency scores was lower for VRS efficiencies, as compared to CRS efficiencies, as indicated by the standard deviation. The standard deviation of the technical efficiencies for CRS ranged from 0.15 to 0.17, while the standard deviation for VRS technical efficiencies ranged from 0.14 to 0.16.

In addition to this, a greater number of local governments are "on the frontier" for VRS efficiencies (which means that these local governments are fully efficient). Under CRS technical efficiencies, between 6 and 11 local governments were fully efficient, while under VRS technical efficiencies, between 17 and 23 local government were fully efficient.

The mean technical efficiencies presented in Table 5-3 indicate that although some local governments are fully efficient (relative to other local governments), the majority of local governments have room for improvement. The mean technical efficiencies are well above 50%, indicating that local governments are generally performing well. Using these numbers it will be possible to give an efficiency factor which is achievable for local governments to attain.

Figure 5-1 - DEA (VRS) Technical Efficiencies for Model 1 (Single Group Analysis) in 2015-16



As an example of the fact that there is room for improvement, Figure 5-1 shows all the local governments with their efficiencies ranked by their efficiency scores for Model 1 under the single grouping. As can be seen, the majority of them are less than fully efficient (i.e. have a technical efficiency of less than 1). However, it should also be noted that all the local governments have a technical efficiency greater than 0.5.

5.2.1.2 Grouping of Local Governments

Efficiency Calculations

The following analysis grouped local governments into one of five groups, namely: Interface, Large Rural, Metropolitan, Regional Centre and Small Rural. For each group, DEA was conducted. The goal of this analysis was to compare only local governments with similar attributes to one another rather than examining all local governments as one group (with the assumption that they all share the same attributes and environments). As DEA is a method for computing relative efficiencies, grouping similar local governments with one another tends to yield different efficiencies than by considering all local governments as a single group.

It should be noted that the results presented in this section are averages of all local governments in their particular grouping and do not represent each local government's performance on an individual level.

Table 5-4 - DEA Mean Technical Efficiencies for Interface Group of Local Governments

Model	Local Government Group	Mean Technical Efficiency		Standard Deviation of Technical Efficiency		On the frontier	
		CRS	VRS	CRS	VRS	CRS	VRS
1	Interface	0.89	0.91	0.14	0.14	3	6
2	Interface	0.89	0.92	0.13	0.12	4	6
3	Interface	0.94	0.97	0.10	0.08	4	7
4	Interface	0.94	0.94	0.11	0.11	6	8
5	Interface	0.93	0.94	0.11	0.11	4	6

Note, the Mean Technical Efficiencies may also be expressed as percentages, i.e. 89%, 91% and so on.

The Interface group is comprised of 9 local governments. The results indicate that local governments in this group are between 89% and 97% efficient depending on the model. Model 3 produces the highest efficiencies, at 94% (CRS) and 97% (VRS). The lowest efficiency is given by Models 1 and 2 CRS at 89%. The variability of the technical efficiencies ranged from 0.08 to 0.14. The variability of CRS and VRS technical efficiencies was very similar, differing only by 0.02 at most. Model 4 had the highest number of local governments as being fully efficient. Under the CRS and VRS for Model 4, 6 and 8 local governments were considered fully efficient. Model 1 CRS had the least number of local governments as being fully efficient, with only 3 local governments being fully efficient.

Table 5-5 - DEA Mean Technical Efficiencies for Large Rural Group of Local Governments

Model	Local Government Group	Mean Technical Efficiency		Standard Deviation of Technical Efficiency		On the frontier	
		CRS	VRS	CRS	VRS	CRS	VRS
1	Large Rural	0.88	0.95	0.11	0.07	3	10
2	Large Rural	0.83	0.91	0.13	0.09	3	8
3	Large Rural	0.91	0.96	0.09	0.06	3	12
4	Large Rural	0.91	0.94	0.10	0.09	6	10
5	Large Rural	0.90	0.95	0.10	0.08	6	11

The Large Rural group of local governments comprises 19 local governments. The difference between the CRS and VRS efficiency results are a lot wider for Models 1 to 3 than for the Interface group. In addition, the variability of the technical efficiencies is slightly greater in that the standard deviation can differ by up to 0.04 between CRS and VRS. The results can be summarised as follows:

1. The model with the highest mean technical efficiency of 96% was Model 3 under the VRS framework.
2. The model with the lowest mean technical efficiency was Model 2 with 83% under the CRS framework.
3. The model with the highest number of fully efficient local governments was Model 3, with 12 local governments being fully efficient under the VRS framework.

While Models 1, 2 and 3 had the lowest number of local governments being fully efficient with each only having 3 local governments being fully efficient under the CRS framework.

Table 5-6 - DEA Mean Technical Efficiencies for Metropolitan Group of Local Governments

Model	Local Government Group	Mean Technical Efficiency		Standard Deviation of Technical Efficiency		On the frontier	
		CRS	VRS	CRS	VRS	CRS	VRS
1	Metropolitan	0.88	0.95	0.14	0.08	6	11
2	Metropolitan	0.88	0.95	0.14	0.08	5	12
3	Metropolitan	0.90	0.95	0.13	0.07	8	11
4	Metropolitan	0.88	0.95	0.14	0.07	6	12
5	Metropolitan	0.89	0.95	0.13	0.06	6	9

The Metropolitan group of local governments is comprised of 22 local governments. Across the different models and efficiency types, the efficiencies range from 88% to 95%. VRS efficiencies for Models 1, 2, 3, 4 and 5 indicate the highest average VRS efficiency of 95%. Among these models, the number of local governments that are fully efficient in terms of VRS efficiencies range from 11 (Models 1 and 3) to 12 (Models 2 and 4). The variability between CRS and VRS technical efficiencies is quite large with CRS standard deviations of technical efficiencies being almost twice as large as VRS standard deviations of technical efficiencies.

Table 5-7 - DEA Mean Technical Efficiencies for Regional Centre Group of Local Governments

Model	Local Government Group	Mean Technical Efficiency		Standard Deviation of Technical Efficiency		On the frontier	
		CRS	VRS	CRS	VRS	CRS	VRS
1	Regional Centre	0.94	0.95	0.09	0.09	6	7
2	Regional Centre	0.96	0.96	0.09	0.09	7	8
3	Regional Centre	0.94	0.96	0.09	0.07	6	7
4	Regional Centre	0.97	0.97	0.06	0.06	7	8
5	Regional Centre	0.97	0.98	0.04	0.04	5	7

The Regional Centre group of local governments consists of 10 local governments. Relative to one another, this group of local governments is highly efficient. In other words, the efficiency scores are quite close to one another, as indicated by the high average technical efficiencies and small standard deviations of the technical efficiencies. For example, the VRS mean technical efficiencies range between 94% and 99%. Under the CRS framework, all models have 5 to 7 local governments as being fully efficient. While under the VRS framework, all models have 7 to 8 local governments as being fully efficient.

Table 5-8 - DEA Mean Technical Efficiencies for Small Rural Group of Local Governments

Model	Local Government Group	Mean Technical Efficiency		Standard Deviation of Technical Efficiency		On the frontier	
		CRS	VRS	CRS	VRS	CRS	VRS
1	Small Rural	0.91	0.95	0.10	0.07	8	11
2	Small Rural	0.90	0.94	0.11	0.09	8	11
3	Small Rural	0.95	0.98	0.07	0.04	8	15
4	Small Rural	0.92	0.98	0.10	0.05	7	12
5	Small Rural	0.92	0.97	0.08	0.05	8	11

The Small Rural group of local governments is comprised of 19 local governments. Relative to one another, these local governments tend to be highly efficient. This is indicated by both the high mean technical efficiencies and low standard deviations of the technical efficiencies. The models give mean technical efficiencies of 90% to 99%. The model with the greatest number of local governments being fully efficient is Model 3 under the VRS framework, with 15 of the 19 local governments being considered fully efficient.

Table 5-9 - DEA Mean Technical Efficiencies averaged across all local government groups 2015-16

Model	Mean Technical Efficiency		Standard Deviation of Technical Efficiency		On the frontier	
	CRS	VRS	CRS	VRS	CRS	VRS
1	0.90	0.94	0.12	0.09	26	45
2	0.88	0.94	0.13	0.09	27	45
3	0.92	0.96	0.10	0.06	29	52
4	0.92	0.96	0.11	0.08	32	48
5	0.92	0.96	0.11	0.07	29	44

The results of the multiple group analysis indicate that the majority of local governments are highly efficient. Under almost all model specifications, except for Model 2, the technical efficiency under both the CRS and VRS framework is above 90%. In addition, under the VRS framework, the majority of local governments are considered to be fully efficient, as indicated by the number of local government that are on the frontier.The results indicate the relative performance of local governments when they are only compared with local governments of a similar nature. Naturally, the mean technical efficiencies are higher.

5.3 Calculation of X-factors

TFP (Malmquist Index)

A component of the formula to calculate the X-factor is the TFPC (Total Factor Productivity Change) (see Sections 4.4 and 4.5 for more details). To this end, the Malmquist index was computed in order to obtain a TFPC. The Malmquist index was computed over the financial years of 2010-11 up until 2015-16. Dollar amounts for years preceding the 2015-16 financial year were converted to 2015-16 financial year dollar amounts through the use of an annualized CPI[12].

Typically, the Malmquist index allows for the quantification of change between economies. In this report, it is used to account for the change of efficiency indicators between two different years. Technical efficiency change indicates the change in efficiency from one year to the next. This is can be described as the improvement in productivity through further adoption of existing technologies. In other words, it is representative of local governments moving closer to (or further from) the frontier. If the efficiency of a local government has increased from one year to the next, the technical efficiency change will be greater than one. If efficiency has decreased from one year to the next, the technical efficiency change will be less than one. No change in technical efficiency is indicated by a value of one. This change is determined by the production frontier in the previous year and in the subsequent year (i.e. two different production frontiers are used in the calculation of the technical efficiency change).

[12] The annualised CPI rates used in the analysis for the period 2010-2015 are 96.1, 99.3, 101.0, 103.5, 106.1 and 107.7 respectively.

Technological change compares the production technology of, in this report, two consecutive years. Simply put, it compares the ability of a local government in one year to efficiently transform inputs into outputs with the same local government's ability in another year to efficiently transform inputs into outputs. This represents the expansion or contraction of the production frontier – that is, the best local governments getting better or worse. If the technological change is greater than one, then the local government in the subsequent year had a superior ability to efficiently transform inputs into outputs. If the technological change is less than one, then the local government in the previous year had a superior ability to efficiently transform inputs into outputs (see, for example, Worthington (1999)). The technological change is essentially a ratio of how well a local government performs in both years with inputs from a previous year and how well a local government performs in both years with inputs from a subsequent year.

Table 5-10 - Malmquist Index Results for DEA

Model	Geometric Mean of Malmquist Index over time	Number of Local Governments with increasing efficiency	Geometric Mean of Technical Efficiency change over time	Geometric Mean of Technological change over time
	DEA	DEA	DEA	DEA
1	0.996	39	1.0001	0.9959
2	0.994	29	1.005	0.990
3	0.995	39	1.002	0.992
4	0.985	20	0.993	0.992
5	0.977	13	1.001	0.976

The Malmquist index is a combination of the Technical efficiency change over time, and the Technological change over time. These results are given in Table 5-20. For the DEA analysis (both CRS and VRS), the Malmquist index was in the range of 0.977 to 0.995 for Models 1 to 5. The Malmquist index values for Models 1 to 5 indicate that, according to the DEA methodology, local governments (as a group) are becoming less efficient over time. As can be seen from Table 5-20, the number of local governments with increasing efficiency over time ranges from 13 to 39.

The following figures track the Malmquist index (for the single group analysis) over time by grouping local governments into the groups listed in Appendix A.

Figure 5-2 - DEA Malmquist Index (Single Group Analysis) for Model 1 over time grouped by Local Government Groupings in Appendix A

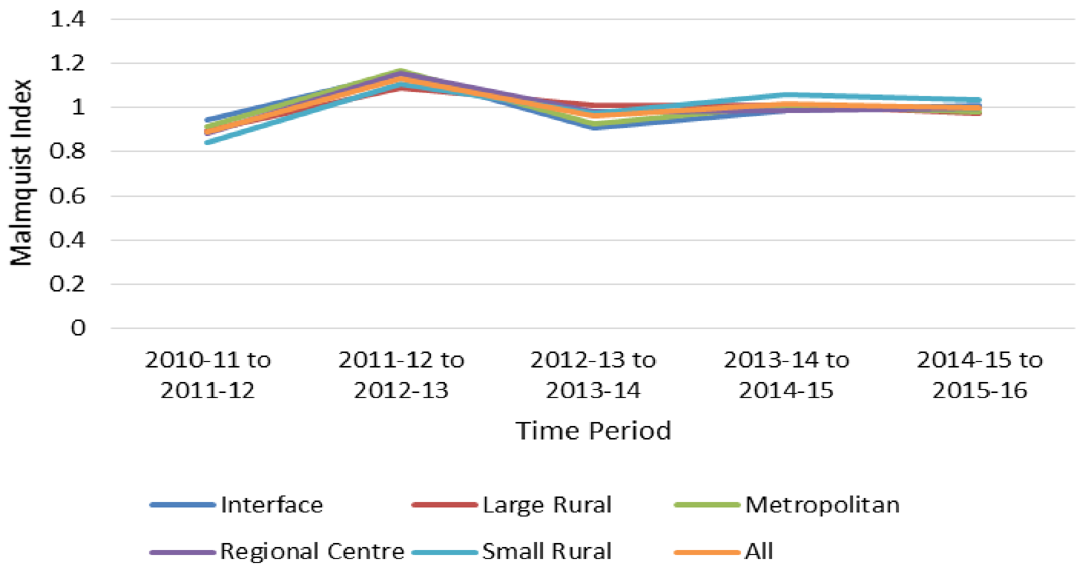


Figure 5-2 displays the Malmquist index over time for Model 1 under the DEA framework for single group analysis. The results are averaged by local government groupings (see Appendix A) as well as giving the overall average. As can be seen there is no large difference between the various groupings. This indicates that differences between local governments are not due to differences between groupings. In other words, there are high performing local governments and low performing local governments in each group.

Figure 5-3 - DEA Malmquist Index (Single Group Analysis) for Model 2 over time grouped by Local Government Groupings in Appendix A

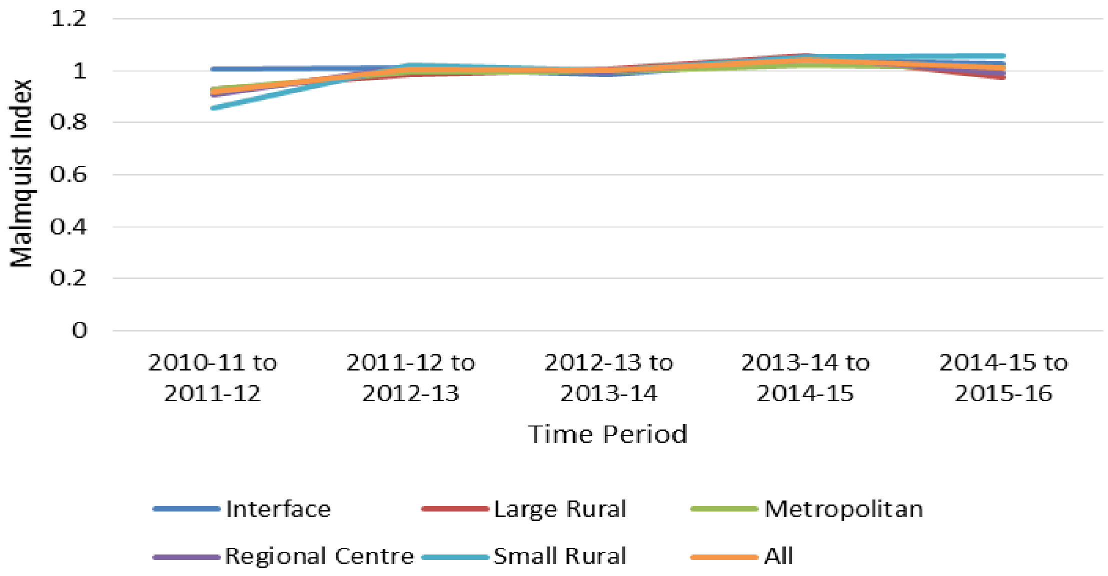


Figure 5-3 displays the Malmquist index over time for Model 2 under the DEA framework for single group analysis. The results are averaged by local government groupings (see Appendix A) as well as giving the overall average. As can be seen there is no large difference between the various groupings. This indicates that differences between local governments are not due to differences between groupings. In other words, there are high performing local governments and low performing local governments in each group.

Figure 5-4 - DEA Malmquist Index (Single Group Analysis) for Model 3 over time grouped by Local Government Groupings in Appendix A

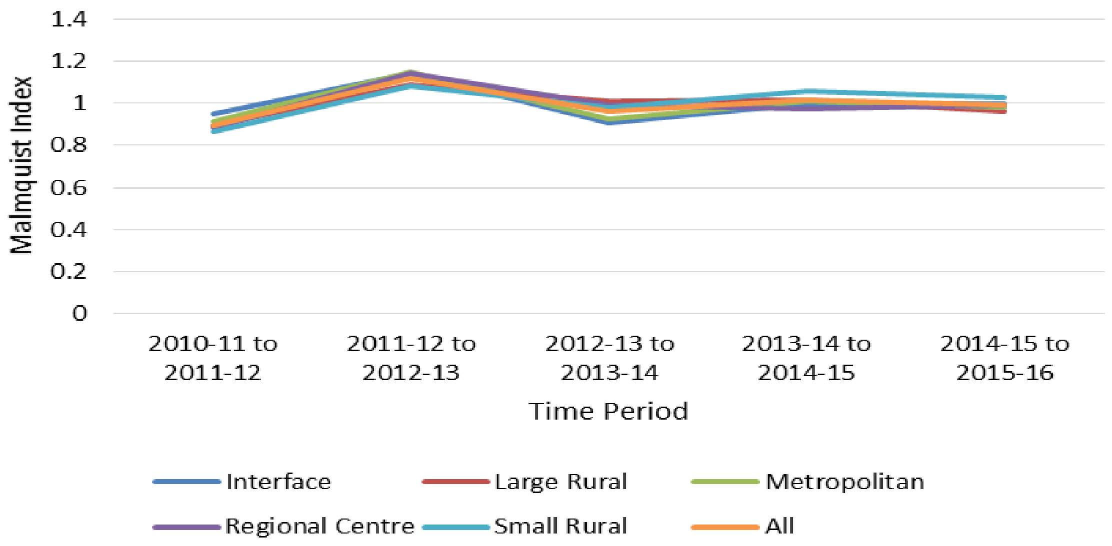


Figure 5-4 displays the Malmquist index over time for Model 3 under the DEA framework for single group analysis. The results are averaged by local government groupings (see Appendix A) as well as giving the overall average. As can be seen there is no large difference between the various groupings. This indicates that differences between local governments are not due to differences between groupings. In other words, there are high performing local governments and low performing local governments in each group.

Figure 5-5 - DEA Malmquist Index (Single Group Analysis) for Model 4 over time grouped by Local Government Groupings in Appendix A

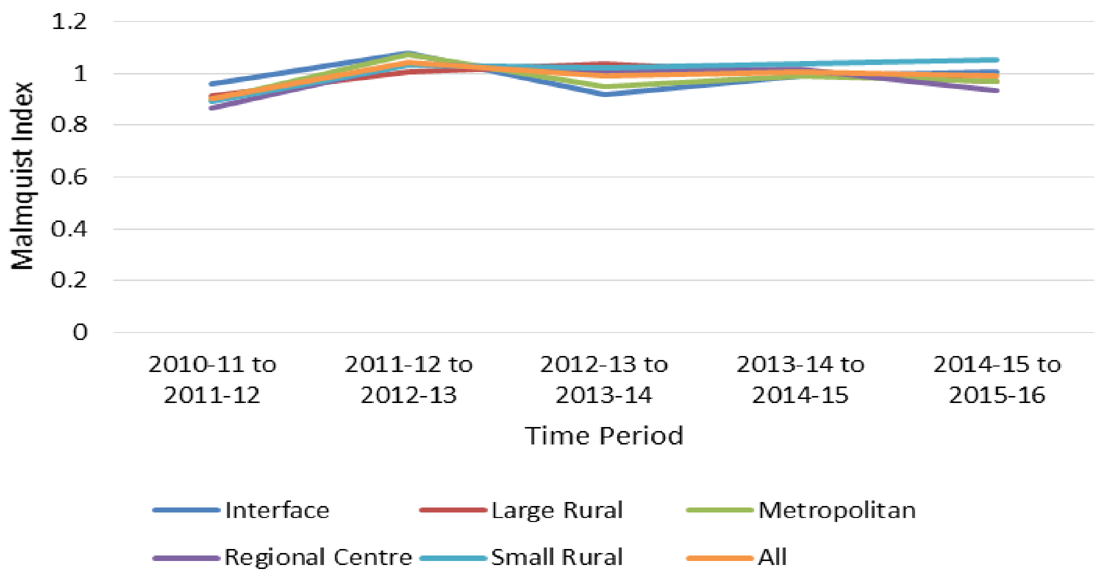


Figure 5-5 displays the Malmquist index over time for Model 4 under the DEA framework for single group analysis. The results are averaged by local government groupings (see Appendix A) as well as giving the overall average. As can be seen there is no large difference between the various groupings. This indicates that differences between local governments are not due to differences between groupings. In other words, there are high performing local governments and low performing local governments in each group. Although there is not a large difference between the groupings, in the final transition (2014-15 to 2015-16), indicates that Small Rural local governments became more efficient while the remaining groups remained the same or slightly decreased in efficiency.

Figure 5-6 - DEA Malmquist Index (Single Group Analysis) for Model 5 over time grouped by Local Government Groupings in Appendix A

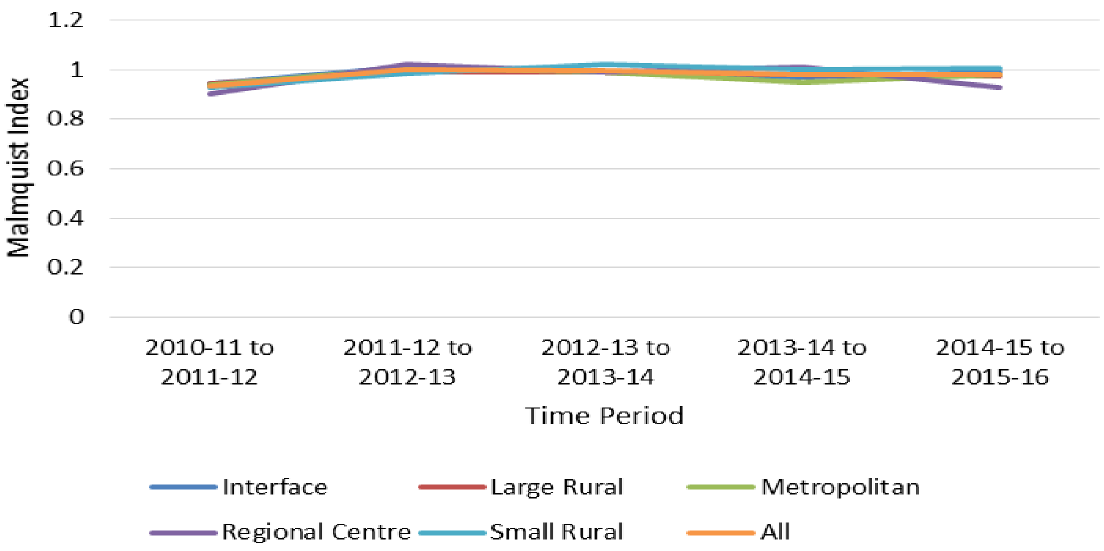
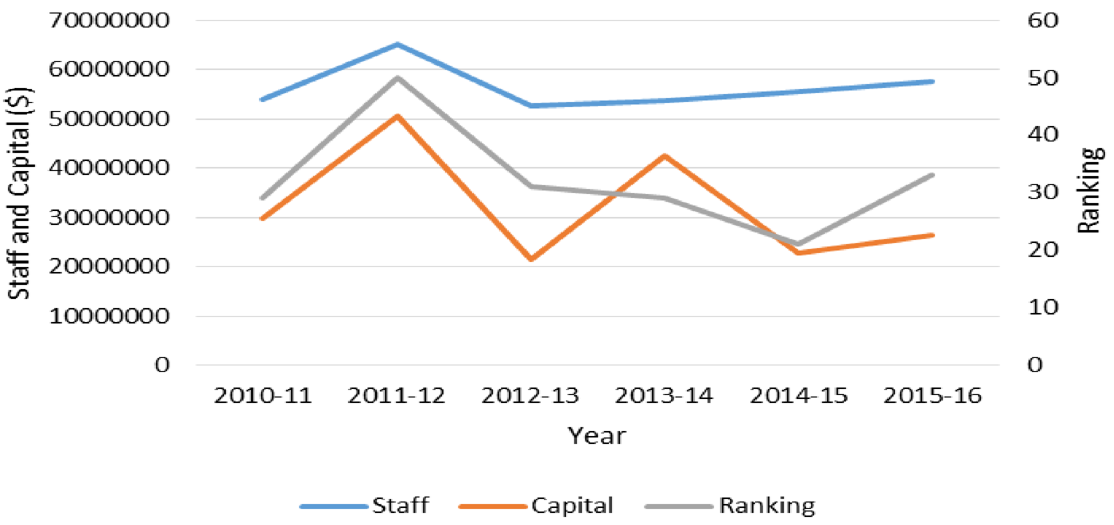


Figure 5-6 displays the Malmquist index over time for Model 5 under the DEA framework for single group analysis. The results are averaged by local government groupings (see Appendix A) as well as giving the overall average. As can be seen there is no large difference between the various groupings. This indicates that differences between local governments are not due to differences between groupings. In other words, there are high performing local governments and low performing local governments in each group.

As an example of the impact of inputs from year to year on each year's technical efficiency, Figure 5-7 was produced.

Figure 5-7 - The impact of changing inputs on local government ranking from year to year for local government Metropolitan[13]



As can be seen from Figure 5-7, as inputs decrease, the ranking of Metropolitan becomes a higher ranking (or decreases in number as Figure 5-7 shows). This graph demonstrates the fact that if local governments can decrease their inputs, they will become more efficient.

The following table gives the Malmquist index results for the DEA multiple group analysis.

Table 5-11 - Malmquist Index results for Multiple Group Analysis

Model	Geometric Mean of Malmquist Index over time	Number of Local Governments with increasing efficiency	Geometric Mean of Technical Efficiency change over time	Geometric Mean of Technological change over time
1	0.993	34	0.999	0.994
2	0.994	34	1.003	0.991
3	0.993	36	1.001	0.993
4	0.985	18	1.001	0.983
5	0.976	11	0.998	0.978

It should be noted that for the multiple group analysis, the Malmquist index (and its associate technical efficiency change and technological change) for each individual local government was computed. This was done based on the technical efficiencies computed by grouping the local governments according to the groupings specified in Table 5-2. This means that the efficiencies were calculated only by reference to other local governments within each individual group. The resultant Malmquist indexes (and associated technical efficiency changes and technological changes) in Table 5-21 were then computed by averaging all the individual Malmquist indexes (and associated technical efficiency changes and technological changes). The average Malmquist indexes (and associated technical efficiency changes and technological changes) were not computed by first averaging within groups and then averaging the averages of each group. They were computed by averaging over all 79 local government Malmquist indexes (and associated technical efficiency changes and technological changes).

[13] The councils that make up the Metropolitan group include Banyule, Bayside, Boroondara, Brimbank, Darebin, Frankston, Glen Eira, Greater Dandenong, Hobsons Bay, Kingston, Knox, Manningham, Maribyrnong, Maroondah, Melbourne, Monash, Moonee Valley, Moreland, Port Phillip, Stonnington, Whitehorse, Yarra.

The Malmquist index values for the analysis of local governments in groupings based on similarities are shown above in Table 5-21. The Malmquist index values for Model 1 to 3 are reasonably similar in that they range between 0.993 and 0.994. Model 5 shows a significantly lower Malmquist index value of 0.976. Interestingly, the mean of the technical efficiency change over time is greater than one for Models 2 to 4 while for Models 1 and 5 the value is slightly less than one. The reason that Models 2 to 4 still have a Malmquist index of less than 1 is that the technological change is generally lower for those models. This suggests the local governments are not or are unable (due to government requirements) to innovate with their technology.

Figure 5-8 - DEA Malmquist Index (Multiple Group Analysis) for Model 1 over time grouped by Local Government Groupings in Appendix A

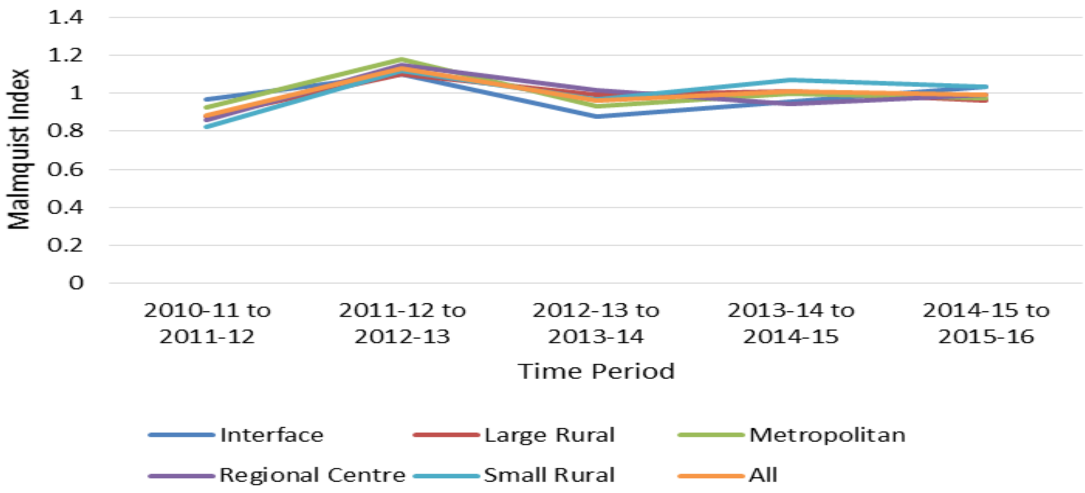


Figure 5-8 displays the Malmquist index over time for Model 1 under the DEA framework for multiple group analysis. The results are averaged by local government groupings (see Appendix A) as well as giving the overall average. As can be seen there is no large difference between the various groupings. This indicates that differences between local governments are not due to differences between groupings. In other words, there are high performing local governments and low performing local governments in each group.

Figure 5-9 - DEA Malmquist Index (Multiple Group Analysis) for Model 2 over time grouped by Local Government Groupings in Appendix A

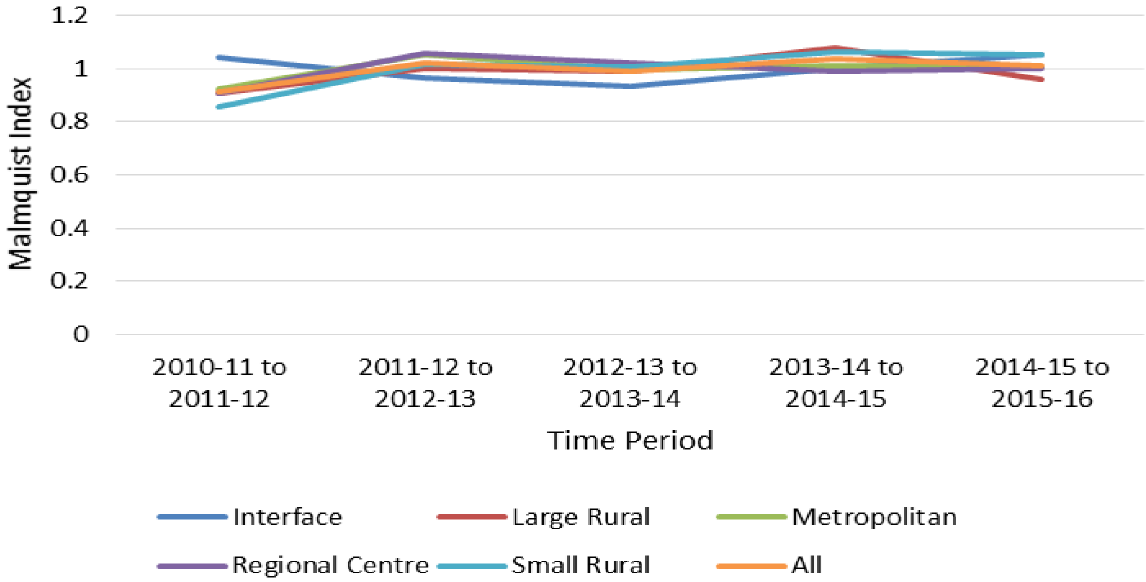


Figure 5-9 displays the Malmquist index over time for Model 2 under the DEA framework for multiple group analysis. The results are averaged by local government groupings (see Appendix A) as well as giving the overall average. For the 2010-11 to 2011-12 financial years there is a significant difference between the Interface local governments and the remaining local government groupings. The Interface local governments have a Malmquist index greater than one while the remaining groupings have a Malmquist index of less than one. After this time period, there is no large difference between the various groupings. This indicates that differences between local governments are not due to differences between groupings. In other words, there are high performing local governments and low performing local governments in each group.

Figure 5-10 - DEA Malmquist Index (Multiple Group Analysis) for Model 3 over time grouped by Local Government Groupings in Appendix A

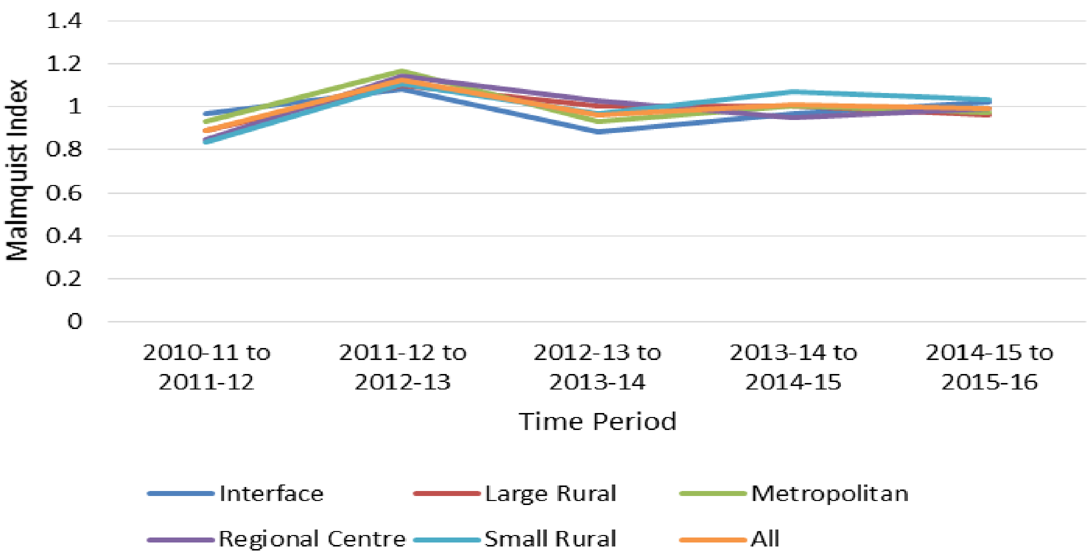


Figure 5-10 displays the Malmquist index over time for Model 3 under the DEA framework for multiple group analysis. The results are averaged by local government groupings (see Appendix A) as well as giving the overall average. As can be seen there is no large difference between the various groupings. This indicates that differences between local governments are not due to differences between groupings. In other words, there are high performing local governments and low performing local governments in each group.

Figure 5-11 - DEA Malmquist Index (Multiple Group Analysis) for Model 4 over time grouped by Local Government Groupings in Appendix A

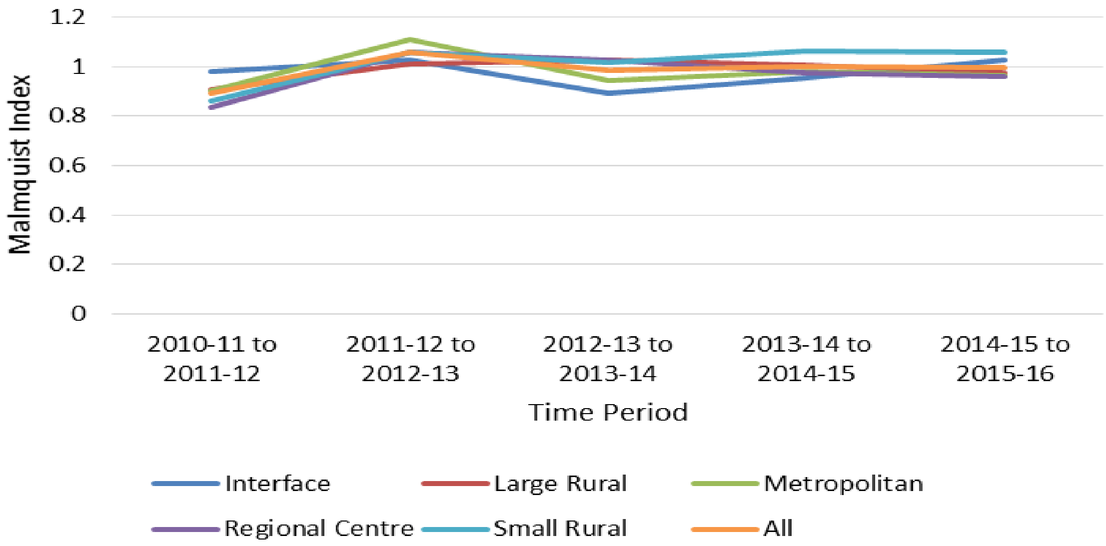


Figure 5-11 displays the Malmquist index over time for Model 4 under the DEA framework for multiple group analysis. The results are averaged by local government groupings (see Appendix A) as well as giving the overall average. As can be seen there is no large difference between the various groupings. However, there are subtle variations. In the period 2012-13 to 2013-14, Interface local governments had a Malmquist index significantly lower than the remaining local government groupings.

Figure 5-12 - DEA Malmquist Index (Multiple Group Analysis) for Model 5 over time grouped by Local Government Groupings in Appendix A

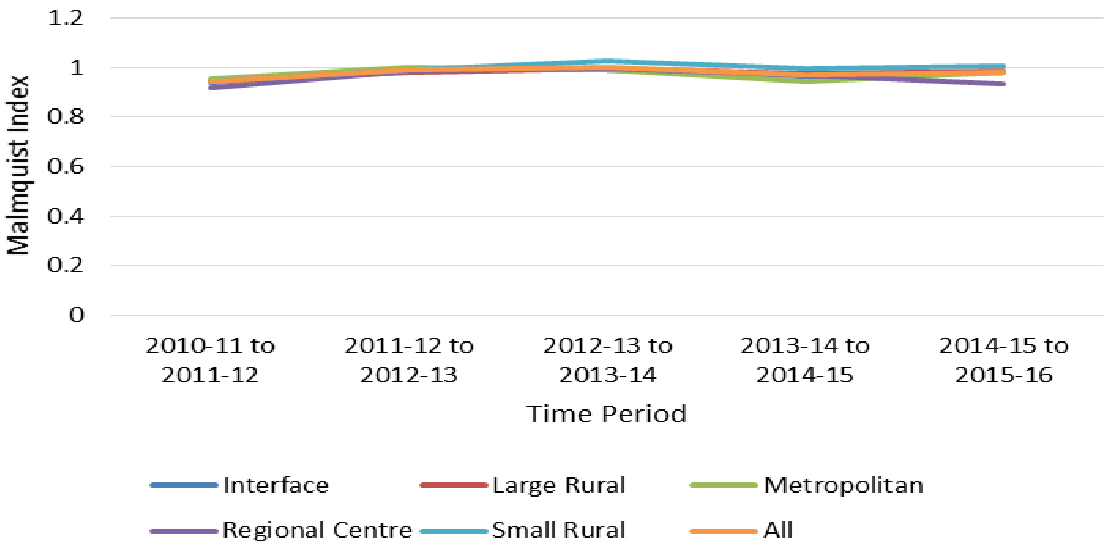


Figure 5-12 displays the Malmquist index over time for Model 5 under the DEA framework for multiple group analysis. The results are averaged by local government groupings (see Appendix A) as well as giving the overall average. As can be seen there is no large difference between the various groupings. This indicates that differences between local governments are not due to differences between groupings. In other words, there are high performing local governments and low performing local governments in each group.

X-factor Computation

There are two approaches to computing the TFPC component of the X-factor. The first (which is termed Method 1 for the purposes of this report) is that the Commission may wish the local governments to attain a minimum increase in efficiency. For example, the Commission may wish there to be a minimum decrease of inputs of 0.05% each year. To this end, the Commission may stipulate that the TFPC is set at 0.05.

On the other hand, the average change in TFP over time is also considered a valid number for the TFPC component of the formula. For example, for Model 1, the Commission may utilize the Malmquist index to stipulate the TFPC. This method is termed Method 2 for the purposes of this report. Given that all Malmquist index results determined that the local governments were decreasing in efficiency over time, the TFPC would be negative. However, as mentioned, the TFPC is bounded below by zero. As such in this analysis, utilising Malmquist index to stipulate the TFPC results in a TFPC of zero.

In addition to this the Commission may wish to consider different scenarios of efficiency increases over time. To this end, scenarios considered were:

- Low: a 2.5% catch up in efficiency over 5 years.
- Medium: a 5% catch up in efficiency over 5 years.
- High: 7.5% catch up in efficiency over 5 years.

The scenario indicates the increase in efficiency over the entire 5 year period. In other words, in the Low scenario, a 2.5% catch up in efficiency over 5 years is equivalent to a 0.5% catch up in efficiency each year over the 5 year period.

The X-factor shows the percentage reduction in costs that local governments would have to achieve to attain the specified efficiency gains according to the scenario (i.e. low, medium or high). For example, In Table 5-22 for Model 1 in the low scenario under the DEA (VRS) methodology, the X-factor is 0.15%. This translates to local governments being required to reduce costs by 0.15% per year to attain the 2.5% increase in efficiency over 5 years.

It should be noted that the results presented in this section are averages of all local governments and do not represent each local government's efficiency factor on an individual level.

Method 1 (Single Group)

Table 5-12 - Efficiency Factor (X-factor) Results using Method 1 for Single Group Analysis

	X-factor					
	Low		Medium		High	
Model	DEA (CRS)	DEA (VRS)	DEA (CRS)	DEA (VRS)	DEA (CRS)	DEA (VRS)
1	0.18	0.15	0.31	0.24	0.44	0.33
2	0.19	0.15	0.33	0.25	0.47	0.35
3	0.17	0.13	0.29	0.22	0.40	0.30
4	0.18	0.14	0.32	0.24	0.45	0.33
5	0.17	0.14	0.29	0.23	0.41	0.32

Table 5-22 gives the X-factors for the scenario in which the local governments are considered as a single group (rather than breaking them into similar groupings such as Interface, Metropolitan etc.). In general, DEA (CRS) X-factors tended to be higher than DEA (VRS) X-factors.

In the scenario labelled as *Low*, the X-factor ranged from 0.13% to 0.19%. In the *Medium* scenario, X-factors ranged from 0.22% to 0.33%. In the *High* scenario, X-factors ranged from 0.30% to 0.47%.

Method 1 (Multiple Groups)

Table 5-13 - Efficiency Factor (X-factor) Results using Method 1 for Multiple Group Analysis

X-factor						
	Low		Medium		High	
Model	DEA (CRS)	DEA (VRS)	DEA (CRS)	DEA (VRS)	DEA (CRS)	DEA (VRS)
1	0.10	0.08	0.15	0.11	0.20	0.13
2	0.11	0.08	0.17	0.11	0.22	0.15
3	0.09	0.07	0.13	0.09	0.17	0.10
4	0.09	0.07	0.13	0.09	0.17	0.12
5	0.09	0.07	0.13	0.09	0.17	0.11

Table 5-23 gives the X-factors for the scenario in which the local governments are considered by their groupings (i.e. Interface, Metropolitan etc.). In general, DEA (CRS) X-factors tended to be higher than DEA (VRS) X-factors.

In the scenario labelled as *Low*, the X-factor ranged from 0.07% to 0.11%. In the *Medium* scenario, X-factors ranged from 0.09% to 0.17%. In the *High* scenario, X-factors ranged from 0.10% to 0.22%. On the whole, these X-factors were generally lower than the X-factors which considered the local governments as a single group. The method of computing the X-factor compares only similar local governments with other similar local governments.

Method 2 (Single Group)

Table 5-14 - Efficiency Factor (X-factor) Results using Method 2 for Single Group Analysis

X-factor						
	Low		Medium		High	
Model	DEA (CRS)	DEA (VRS)	DEA (CRS)	DEA (VRS)	DEA (CRS)	DEA (VRS)
1	0.13	0.10	0.26	0.19	0.39	0.28
2	0.14	0.10	0.28	0.20	0.42	0.30
3	0.12	0.08	0.24	0.17	0.35	0.25
4	0.13	0.09	0.27	0.19	0.40	0.28
5	0.12	0.09	0.24	0.18	0.36	0.27

Table 5-24 gives the X-factors for the scenario in which local governments are considered as a single group. In addition, these X-factors use the Malmquist index to obtain the TFPC. This results in different X-factors than for Method 1. Again DEA (CRS) X-factors were higher than DEA (VRS) X-factors.

In the scenario labelled as *Low*, the X-factor ranged from 0.08% to 0.14%. For the scenario labelled *Medium*, the X-factor ranged from 0.17% to 0.28%, depending on the model of choice. For the *High* scenario, the X-factor ranged from 0.25 to 0.42%.

Method 2 (Multiple Groups)

Table 5-15 - Efficiency Factor (X-factor) Results using Method 2 for Multiple Group Analysis

X-factor						
	Low		Medium		High	
Model	DEA (CRS)	DEA (VRS)	DEA (CRS)	DEA (VRS)	DEA (CRS)	DEA (VRS)
1	0.05	0.03	0.10	0.06	0.15	0.08
2	0.06	0.03	0.12	0.06	0.17	0.10
3	0.04	0.02	0.08	0.04	0.12	0.05
4	0.04	0.02	0.08	0.04	0.12	0.07
5	0.04	0.02	0.08	0.04	0.12	0.06

Table 5-25 gives the X-factors for the scenario in which the local governments are considered by their groupings (i.e. Interface, Metropolitan etc.). In general, DEA (CRS) X-factors tended to be higher than DEA (VRS) X-factors.

In the scenario labelled as *Low*, the X-factor ranged from 0.02% to 0.06%. In the *Medium* scenario, X-factors ranged from 0.04% to 0.12%. In the *High* scenario, X-factors ranged from 0.05% to 0.17%. On the whole, these X-factors were generally lower than the X-factors which considered the local governments as a single group. The method of computing the X-factor compares only similar local governments with each other.

6 Sensitivity Analysis

6.1 Introduction

This section presents the results of the sensitivity analysis. In this section the DEA analysis on local governments as a single group was rerun with modifications to the inputs. This analysis can paint a picture of what sort of efficiencies local governments can attain under different scenarios of varying inputs.

The scenarios considered include both decreases and increases to a local government's inputs. This can assist modelling scenarios in which a local government foresees an increase in certain costs in their operations, resulting in increased inputs. Or, on the other hand, if the local government foresees decreases in the operational inputs, the resultant improvement in efficiency is given.

6.2 Methodology

For the sensitivity analysis, six scenarios were modelled. They are:

- 20% decrease in inputs
- 10% decrease in inputs
- 5% decrease in inputs
- 5% increase in inputs
- 10% increase in inputs
- 20% increase in inputs

Given that DEA is a relative scheme (in other words, efficiencies for one local government are computed relative to other local governments), it is necessary to modify the inputs for only one local government at a time to obtain results. If the inputs of all local governments were modified and used in a single DEA model, the results would be identical to those shown in Section 5.

6.3 Results

The results of the sensitivity analysis are shown below.

20% Decrease in Inputs

Table 6-1 gives the sensitivity analysis results for a 20% decrease in inputs.

Table 6-1 - Sensitivity Analysis Results for a 20% Decrease in Inputs

Model	Mean Technical Efficiency		Percentage Increase/Decrease of Mean Technical Efficiency		Standard Deviation of Technical Efficiency		On the frontier	
	CRS	VRS	CRS	VRS	CRS	VRS	CRS	VRS
1	0.87	0.92	17.57%	13.58%	0.13	0.10	29	42
2	0.84	0.91	18.31%	15.19%	0.15	0.12	25	38

Model	Mean Technical Efficiency		Percentage Increase/Decrease of Mean Technical Efficiency		Standard Deviation of Technical Efficiency		On the frontier	
	CRS	VRS	CRS	VRS	CRS	VRS	CRS	VRS
3	0.89	0.94	17.11%	13.25%	0.13	0.10	36	46
4	0.87	0.93	19.18%	14.81%	0.14	0.10	27	40
5	0.89	0.93	17.11%	13.41%	0.12	0.10	32	46

By decreasing inputs by 20%, local governments can expect to improve their efficiency from anywhere between 13.25% and 19.18%, depending on which model is used to compute efficiencies. Model 4 under the CRS framework indicated the biggest increase in mean technical efficiencies.

10% Decrease in Inputs

Table 6-2 gives the sensitivity analysis results for a 10% decrease in inputs.

Table 6-2 - Sensitivity Analysis Results for a 10% Decrease in Inputs

Model	Mean Technical Efficiency		Percentage Increase/Decrease of Mean Technical Efficiency		Standard Deviation of Technical Efficiency		On the frontier	
	CRS	VRS	CRS	VRS	CRS	VRS	CRS	VRS
1	0.81	0.87	9.46%	7.41%	0.15	0.13	17	26
2	0.78	0.85	9.86%	7.59%	0.17	0.15	14	26
3	0.83	0.89	9.21%	7.23%	0.15	0.13	19	32
4	0.80	0.87	9.59%	7.41%	0.16	0.13	14	26
5	0.82	0.88	7.89%	7.32%	0.14	0.13	18	28

By decreasing inputs by 10%, local governments can expect to improve their efficiency from anywhere between 7.23% and 9.86%, depending on which model is used to compute efficiencies. Model 2 indicated the biggest increase in mean technical efficiency with respect to CRS efficiency. Model 3 VRS efficiency showed the lowest increase at 7.23%.

5% Decrease in Inputs

Table 6-3 gives the sensitivity analysis results for a 5% decrease in inputs.

Table 6-3 - Sensitivity Analysis Results for a 5% Decrease in Inputs

Model	Mean Technical Efficiency		Percentage Increase/Decrease of Mean Technical Efficiency		Standard Deviation of Technical Efficiency		On the frontier	
	CRS	VRS	CRS	VRS	CRS	VRS	CRS	VRS
1	0.77	0.84	4.05%	3.70%	0.16	0.14	13	21
2	0.75	0.82	5.63%	3.80%	0.17	0.15	8	20
3	0.80	0.86	5.26%	3.61%	0.15	0.14	14	25
4	0.76	0.84	4.11%	3.70%	0.16	0.14	9	22
5	0.79	0.85	3.95%	3.66%	0.15	0.14	10	19

By decreasing inputs by 5%, local governments can expect to improve their efficiency from anywhere between 3.61% and 5.63%, depending on which model is used to compute efficiencies. Model 2 indicated the biggest increase in mean technical efficiency with respect to CRS efficiency (at 5.63%). Model 3 VRS efficiency showed the lowest increase at 3.61%.

5% Increase in Inputs

Table 6-4 gives the sensitivity analysis results for a 5% increase in inputs.

Table 6-4 - Sensitivity Analysis Results for a 5% Increase in Inputs

Model	Mean Technical Efficiency		Percentage Increase/Decrease of Mean Technical Efficiency		Standard Deviation of Technical Efficiency		On the frontier	
	CRS	VRS	CRS	VRS	CRS	VRS	CRS	VRS
1	0.71	0.78	-4.05%	-3.70%	0.16	0.16	7	19
2	0.68	0.77	-4.23%	-2.53%	0.17	0.17	6	17
3	0.73	0.80	-3.95%	-3.61%	0.16	0.16	7	21
4	0.70	0.78	-4.11%	-3.70%	0.16	0.15	4	15
5	0.72	0.79	-5.26%	-3.66%	0.15	0.15	4	12

If inputs increase by 5%, local governments can expect a decrease in efficiency from anywhere between -2.53% to -5.26%, depending on which model is used to compute efficiencies. Model 5 indicated the biggest decrease in mean technical efficiency with respect to CRS efficiency (at -5.26%). Model 2 VRS efficiency showed the lowest decrease at -2.53%.

10% Increase in Inputs

Table 6-5 gives the sensitivity results for a 10% increase in inputs.

Table 6-5 - Sensitivity Analysis Results for a 10% Increase in Inputs

Model	Mean Technical Efficiency		Percentage Increase/Decrease of Mean Technical Efficiency		Standard Deviation of Technical Efficiency		On the frontier	
	CRS	VRS	CRS	VRS	CRS	VRS	CRS	VRS
1	0.68	0.76	-8.11%	-6.17%	0.16	0.16	4	13
2	0.65	0.74	-8.45%	-6.33%	0.17	0.17	3	12
3	0.70	0.78	-7.89%	-6.02%	0.16	0.16	5	16
4	0.67	0.75	-8.22%	-7.41%	0.15	0.16	3	11
5	0.69	0.76	-9.21%	-7.32%	0.15	0.15	2	10

If inputs increase by 10%, local governments can expect a decrease in efficiency from anywhere between -6.02% to -9.21%, depending on which model is used to compute efficiencies. Model 5 indicated the biggest decrease in mean technical efficiency with respect to CRS efficiency (at -9.21%). Model 3 VRS efficiency showed the lowest decrease at -6.02%.

20% Increase in Inputs

Table 6-6 gives the sensitivity results for a 20% increase in inputs.

Table 6-6 - Sensitivity Analysis Results for a 20% Increase in Inputs

Model	Mean Technical Efficiency		Percentage Increase/Decrease of Mean Technical Efficiency		Standard Deviation of Technical Efficiency		On the frontier	
	CRS	VRS	CRS	VRS	CRS	VRS	CRS	VRS
1	0.63	0.70	-14.86%	-13.58%	0.15	0.17	1	9
2	0.60	0.69	-15.49%	-12.66%	0.16	0.18	1	9
3	0.65	0.73	-14.47%	-12.05%	0.15	0.17	1	9
4	0.61	0.70	-16.44%	-13.58%	0.14	0.17	1	10
5	0.64	0.70	-15.79%	-14.63%	0.13	0.15	0	8

If inputs increase by 20%, local governments can expect a decrease in efficiency from anywhere between -12.05% to -16.44%, depending on which model is used to compute efficiencies. Model 4 indicated the biggest decrease in mean technical efficiency with respect to CRS efficiency (at -16.44%). Model 3 VRS efficiency showed the lowest decrease at -12.05%.

7 Conclusions and recommendations

7.1 Introduction

This report has analysed the productivity of local governments using the direct approach of DEA. The results for local government efficiency in the 2015-16 financial year were reported. Five different input/output modelling frameworks were considered. These frameworks were devised according to peer-reviewed literature and consultation with the Commission. The local governments were considered as a single group (i.e. comparing all the local governments to each other), and considered in separate groups according to groupings stipulated by the Commission.

In addition to this, total factor productivity from the 2010-11 financial year to the 2015-16 financial year was computed, yielding total factor productivity change over this period. These results have been used to compute the efficiency factor (X-factor) for the local governments under various input-output modelling frameworks for Data Envelopment Analysis.

7.2 Conclusions

The following conclusions are made by PAG:

- The models considered for the efficiency computations are robust in terms of encompassing a broad range of inputs and outputs which are common to all local governments. The Commission can consider which model specification it deems appropriate for its purposes of setting an efficiency factor
- DEA was utilised to compute local government efficiency and resultant efficiency factors. Of the DEA techniques utilised, the more robust method of estimating the efficiencies is the DEA with variable returns to scale. This is due to its more realistic assumptions regarding the scale efficiency of local governments. If the Commission chooses to use a DEA framework for the computation of the efficiency factor, PAG recommends using the DEA (VRS) framework.
- On the basis of the literature review, the specification of inputs and outputs of Model 1 is considered to be preferred as it comprehensively and succinctly covers all the necessary inputs and outputs pertinent to local government operations.
- Analysis was conducted by considering all local governments as a single group and by considering local governments in relevant sub groups. The Commission has the choice to utilise results from either form of analysis. The analysis utilising sub groups looked at local governments in groups in which local governments were of a similar nature
- The Commission has a choice whether to use Method 1 or Method 2 for setting the TFPC in calculating the efficiency factor. Method 1 allows the Commission to stipulate the TFPC based on what it believes the figure should be so as to encourage a certain minimum increase in efficiency. Method 1 makes no reference to any historic patterns of the Malmquist index. Method 2 considers the TFPC to be linked to the Malmquist index (bounded below by zero), which takes into account the historic movements in productivity.
- The calculation of the X-factor scores was robust to a range of alternative specifications. The Commission can choose between a low range of efficiency increase (2.5% increase over 5

years), a medium range of efficiency increase (5% increase over 5 years), and a high range of efficiency increase (7.5% increase over 5 years).

- Based on sensitivity analysis, local governments can improve their efficiency if they decrease their inputs.

A Appendix – Local Government Groupings

The following table lists the group to which each local government belongs to for the purposes of the Multiple Group Analysis. This list was provided by the Commission.

Table A-1 - Local Government Groupings

Local Government	Group
Alpine (S)	Small Rural
Ararat (RC)	Small Rural
Ballarat (C)	Regional Centre
Banyule (C)	Metropolitan
Bass Coast (S)	Large Rural
Baw Baw (S)	Large Rural
Bayside (C)	Metropolitan
Benalla (RC)	Small Rural
Boroondara (C)	Metropolitan
Brimbank (C)	Metropolitan
Buloke (S)	Small Rural
Campaspe (S)	Large Rural
Cardinia (S)	Interface
Casey (C)	Interface
Central Goldfields (S)	Small Rural
Colac Otway (S)	Large Rural
Corangamite (S)	Large Rural
Darebin (C)	Metropolitan
East Gippsland (S)	Large Rural
Frankston (C)	Metropolitan
Gannawarra (S)	Small Rural
Glen Eira (C)	Metropolitan
Glenelg (S)	Large Rural

Local Government	Group
Golden Plains (S)	Large Rural
Greater Bendigo (C)	Regional Centre
Greater Dandenong (C)	Metropolitan
Greater Geelong (C)	Regional Centre
Greater Shepparton (C)	Regional Centre
Hepburn (S)	Small Rural
Hindmarsh (S)	Small Rural
Hobsons Bay (C)	Metropolitan
Horsham (RC)	Regional Centre
Hume (C)	Interface
Indigo (S)	Small Rural
Kingston (C)	Metropolitan
Knox (C)	Metropolitan
Latrobe (C)	Regional Centre
Loddon (S)	Small Rural
Macedon Ranges (S)	Large Rural
Manningham (C)	Metropolitan
Mansfield (S)	Small Rural
Maribyrnong (C)	Metropolitan
Maroondah (C)	Metropolitan
Melbourne (C)	Metropolitan
Melton (C)	Interface
Mildura (RC)	Regional Centre
Mitchell (S)	Large Rural
Moira (S)	Large Rural
Monash (C)	Metropolitan
Moonee Valley (C)	Metropolitan

Local Government	Group
Moorabool (S)	Large Rural
Moreland (C)	Metropolitan
Mornington Peninsula (S)	Interface
Mount Alexander (S)	Large Rural
Moyne (S)	Large Rural
Murrindindi (S)	Small Rural
Nillumbik (S)	Interface
Northern Grampians (S)	Small Rural
Port Phillip (C)	Metropolitan
Pyrenees (S)	Small Rural
Queenscliffe (B)	Small Rural
South Gippsland (S)	Large Rural
Southern Grampians (S)	Large Rural
Stonnington (C)	Metropolitan
Strathbogie (S)	Small Rural
Surf Coast (S)	Large Rural
Swan Hill (RC)	Large Rural
Towong (S)	Small Rural
Wangaratta (RC)	Regional Centre
Warrnambool (C)	Regional Centre
Wellington (S)	Large Rural
West Wimmera (S)	Small Rural
Whitehorse (C)	Metropolitan
Whittlesea (C)	Interface
Wodonga (C)	Regional Centre
Wyndham (C)	Interface
Yarra (C)	Metropolitan

Local Government	Group
Yarra Ranges (S)	Interface
Yarriambiack (S)	Small Rural

B Appendix – Data collection

Data sources

Data were obtained from multiple sources:

- ALG1 Road Length and Expenditure 2010-11 (Provided by the Commission)
- ALG1 Road Length and Expenditure 2011-12 (Provided by the Commission)
- ALG1 Road Length and Expenditure 2012-13 (Provided by the Commission)
- ALG1 Road Length and Expenditure 2013-14 (Provided by the Commission)
- ALG1 Road Length and Expenditure 2014-15 (Provided by the Commission)
- ALG1 Road Length and Expenditure 2015-16 (Provided by the Commission)
- VGC1 Expenditure and Revenue 2010-11 (Provided by the Commission)
- VGC1 Expenditure and Revenue 2011-12 (Provided by the Commission)
- VGC1 Expenditure and Revenue 2012-13 (Provided by the Commission)
- VGC1 Expenditure and Revenue 2013-14 (Provided by the Commission)
- VGC1 Expenditure and Revenue 2014-15 (Provided by the Commission)
- VGC1 Expenditure and Revenue 2015-16 (Provided by the Commission)
- ABS1 Capital Outlays and Sales 2010-11 (Provided by the Commission)
- ABS1 Capital Outlays and Sales 2011-12 (Provided by the Commission)
- ABS1 Capital Outlays and Sales 2012-13 (Provided by the Commission)
- ABS1 Capital Outlays and Sales 2013-14 (Provided by the Commission)
- ABS1 Capital Outlays and Sales 2014-15 (Provided by the Commission)
- ABS1 Capital Outlays and Sales 2015-16 (Provided by the Commission)
- ABS2 Balance Sheets 2010-11 (Provided by the Commission)
- ABS2 Balance Sheets 2011-12 (Provided by the Commission)
- ABS2 Balance Sheets 2012-13 (Provided by the Commission)
- ABS2 Balance Sheets 2013-14 (Provided by the Commission)
- ABS2 Balance Sheets 2014-15 (Provided by the Commission)
- ABS2 Balance Sheets 2015-16 (Provided by the Commission)
- LGV1 Council Employment 2010-11 (Provided by the Commission)
- LGV1 Council Employment 2011-12 (Provided by the Commission)
- LGV1 Council Employment 2012-13 (Provided by the Commission)
- LGV1 Council Employment 2013-14 (Provided by the Commission)
- LGV1 Council Employment 2014-15 (Provided by the Commission)
- LGV1 Council Employment 2015-16 (Provided by the Commission)
- VLGAS Region by Councils (Provided by the Commission)
- VGC Annual Reports (http://www.dtpli.vic.gov.au/local-government/victoria-grants-commission/annual-reports-and-consultations)
- Australian Bureau of Statistics: 1379.0.55.001 - National Regional Profile, 2010-14

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