Essential Services Commission

Local Government – Measuring Productivity Using a Direct Method

Comparison of Alternative Models

Final Report
December 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 Essential Services Commission (the ESC) 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.

PAG is under no obligation in any circumstance to update this report, in either oral or written form, for events occurring after the report has been issued in final form.

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

Third Party Reliance

This report is solely for the purpose set out in this report and for the ESC's information, and is not to be used for any other purpose or distributed to any other party without PAG's prior written consent.

Other than our responsibility to the ESC, neither PAG nor any member or employee of PAG undertakes responsibility arising in any way from reliance placed by a third party on this report. Any reliance placed is that party's sole responsibility.

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.

PREDICTIVE ANALYTICS GROUP

CONTENTS

1 Introduction

1.1 Purpose and Conclusion

As part of a broader program of works relating to the Implementing a Fair Go Rates System, the Essential Services Commission **(the Commission)** engaged Predictive Analytics Group **(PAG)** in December 2016 to measure the productivity of local governments in Victoria and then use the efficiency scores to compute efficiency factors for the Commission to consider. Guided by similar studies undertaken in other jurisdictions across Australia and the academic literature, PAG employed a quantitative method known as Data Envelopment Analysis **(DEA)** to measure productivity.

Feedback was sought from the local governments and peak bodies on the findings outlined in the original report released in September 2017. The feedback focused on the model specifications in particular, the inputs and outputs used, the lack of any use of community satisfaction data in the quantitative modelling and the development of service level DEA models that use the services provided by councils as the model outputs. The purpose of this report is to address some of the concerns by the local governments.

This report compares the results of the original and the updated DEA models. Among the newly specified models outlined in this report are a shared input model and a waste services model. Additional modelling has also been undertaken with data relating to recent community satisfaction surveys published by the Department of Environment, Land, Water and Planning.

The variance found between the original and revised models is negligible (approximately +/- 10%) and as such the conclusions from the original report hold. To explain the consistency between models, we note that the physical quantities such as number of business, households etc. whether observed at the aggregate or disaggregate levels (represented by services that councils have direct control over) are fundamentally driven by changes in population. People drive consumption in council services as well as demand for business, houses, kilometres of road laid, waste collected etc. Since the underlying driver is the same, i.e. changes in population from year to year and across local government areas, it is reasonable that the marginal impact is consistently reflected in the data both at the disaggregate and aggregate level as represented by the original DEA and revised DEA models.

1.2 Structure of this Report

The structure of this report is as follows:

- Part 2 outlines the source of each variable used in the modelling.
- Part 3 provides an overview of the results of comparing the original and alternative model specifications. The alternative model specifications have the following properties:
    1. they exclude capital expenditure ($) and depreciation ($) as inputs; and

2. they refine the DEA specification of Model 1 to comprise of Operational Expenditure ($) and Staffing ($) as inputs and Businesses, Households and Roads as outputs.

- Part 4 presents the results of a DEA model that incorporates the results of the aforementioned community satisfaction survey.
- Part 5 outlines the results of three alternative DEA models that include service level data as outputs, namely:
  - a shared input DEA using Operating Expenses ($) (excluding depreciation) as the input and services provided by the council as the output;
  - a shared input DEA specification using service data contained within the LGPRF dataset as the outputs; and
  - a waste management DEA model that uses inputs and outputs relating specifically to waste management.
- Part 6 presents the results of a DEA model that includes population as an output.

2 Data Sources

The data used to facilitate the development of all models has been summarised below. The table below summarises the inputs used in the DEA models presented in this report.

Table 2-1 – 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 ($)	Operational Expenditure (not including depreciation and amortisation)[1].	VGC1 (Total Expenses 01999: Total Expenditure).
Depreciation ($)	Depreciation and amortisation.	VGC1 (Total Expenses 01999: Depreciation & Amortisation).
Waste Collection Expenditure ($)	Total Expenditure on Waste Management (not including Depreciation & Amortisation).	VGC1 (Waste Management Total 01599: Total Expenditure).
Population Density	Population density 2016 persons/ km2.	Australian Bureau of Statistics: 3218.0 - Regional Population Growth, Australia, 2016.
Waste Cost Disposal Index	Indexed total expenditure on waste management (not including Depreciation & Amortisation).	VGC1 (Waste Management Total 01599: Total Expenditure).

The table below summarises the outputs used in the DEA models presented in this report.

Table 2-2 –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))

[1] **Note:** Models in which Staff ($) has been included as a separate input such as the revised Model 1 have also had Staff ($) removed from the Operational Expenses as well.

Outputs	Definition	Source
Waste Collected	Amount of waste collected in tonnes	VLGAS (Tonnes Collected)
Community Satisfaction Scores	Overall community satisfaction score attributed to that particular council's grouping	Local Government Community Satisfaction Survey 2016 State-Wide Research Report. Coordinated by the Department of Environment, Land, Water and Planning on behalf of Victorian Councils
Planning Application Processing	Median number of days taken between receipt of a planning application and a decision on the application.	LGPRF 2015-16
Library Loans	Number of library collection item loans per library collection item.	LGPRF 2015-16
Animal Management Requests	Average number of days it has taken for council to action animal management requests.	LGPRF 2015-16
Food Complaints	Average number of days it has taken for council to action food complaints received from members of the public about the safety or handling of food.	LGPRF 2015-16
Total Garbage and Recyclables Collected	Garbage and recyclables (in tonnes) collected by the municipality.	Data collected by Sustainability Victoria and provided to PAG by the Commission.
Implied Recycling Rate	Recyclable waste as a proportion of total waste collected.	Data collected by Sustainability Victoria and provided to PAG by the Commission.
Population	Estimated Resident Population at 30 June 2016.	Australian Bureau of Statistics: 3218.0 - Regional Population Growth, Australia, 2016.

3 Original and Alternative Model Comparison

Several alternative DEA models were developed by altering the original DEA model specifications. These alterations involved:

- excluding capital expenditure ($) and depreciation ($) as DEA inputs; and
- revising the Model 1 DEA specification to comprise of: Operational Expenditure ($) + Staffing ($) = Businesses + Households + Roads.

The results of the alternative models have been compared to those of the originals and the results detailed below.

3.1 Specification of Original and Revised models

The table below provides an overview of the inputs and outputs of the five original DEA models.

Table 3-1 – Original 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

The table below summarises the inputs and outputs of the five alternative DEA models.

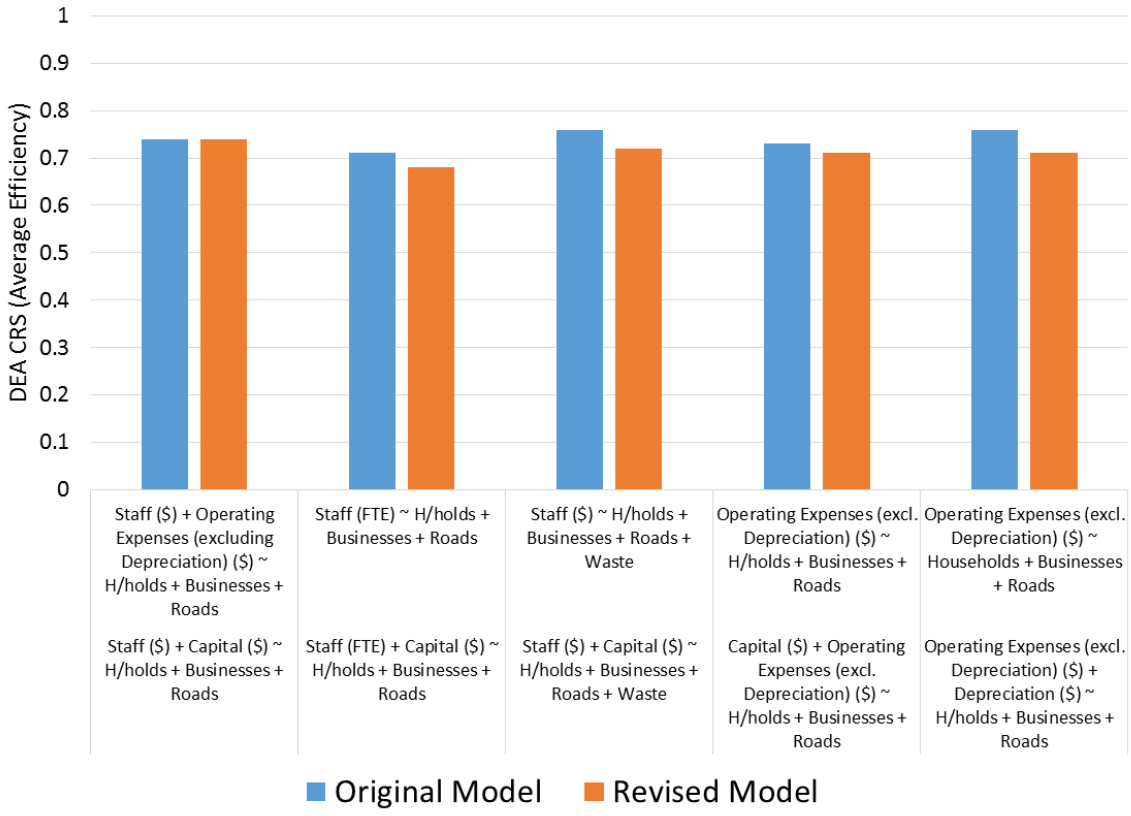
Table 3-2 - Revised Modelling Framework Inputs and Outputs

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

3.2 Single Group Result Comparison

This section details the results of a comparison between each of the original and revised DEA models when the efficiency of the municipalities are measured as a single group. The chart below outlines the difference between the average CRS value of the original and revised models.[2]

Figure 3-1 - Single Group DEA Original and Revised Model CRS Averages[3]



The above figure indicates that the largest difference is between the original and revised Model 5, with the revised model average CRS 0.05 (5%) lower than the original. As the greatest difference between the models is only 5%, the differences between the models in the figure above should not be considered statistically significant. The chart below shows the difference between the average VRS of the original and revised models.[4]

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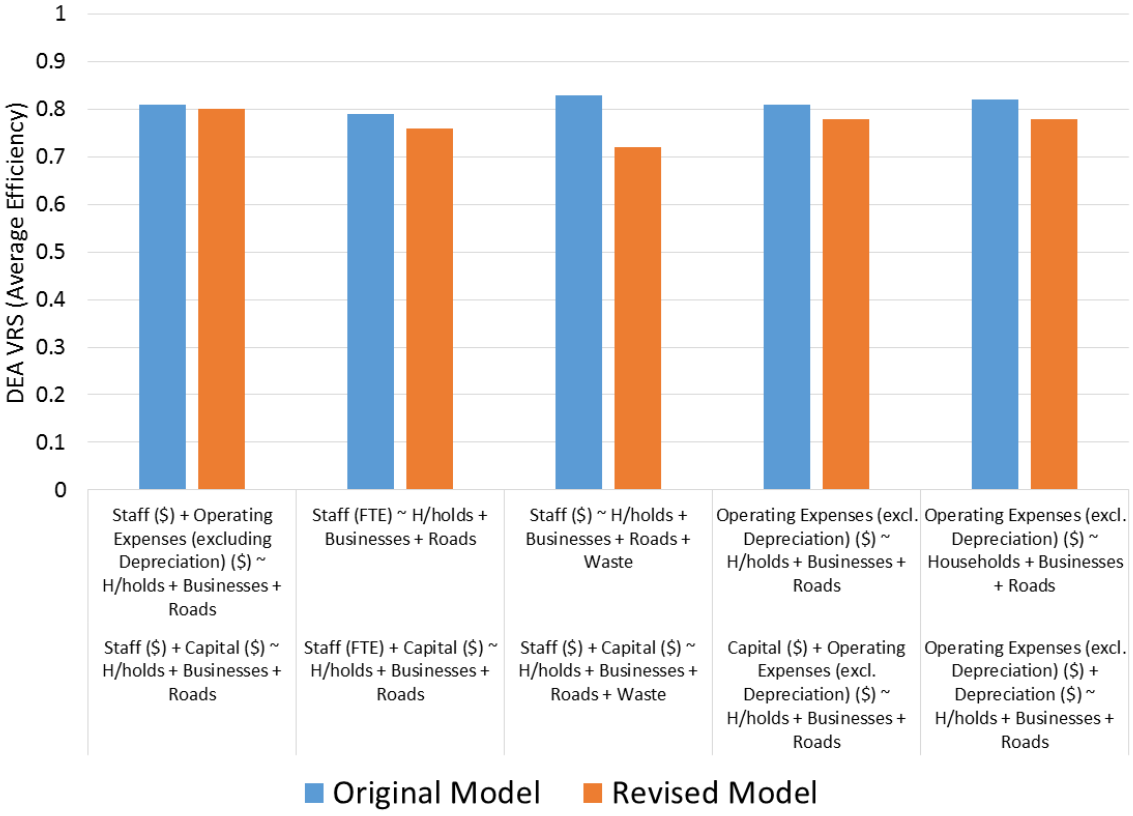
[2] The average CRS value is the average Constant Return to Scale efficiency across all municipalities included in a given DEA model.

[3] The difference between revised Model 1 and revised models 4 and 5 is driven by the fact that the inputs in Model 1 are dis-aggregated. In particular, staffing expenditure is removed from overall operating expenditure and included as a separate input. As staffing expenditure across municipalities will make up differing proportions of overall operating expenses, these differences are reflected in the model results.

[4] The average VRS value is the average Variable Return to Scale efficiency across all municipalities included in a given DEA model.

Figure 3-2 - Single Group DEA Original and Revised Model VRS Averages



The figure above indicates that the largest difference exits between the original and revised Model 3, where the average VRS of the revised model is 0.11 (11%) lower than that of the original. Although the largest difference between the models is 11%, it should be noted the municipalities had on average, comparatively lower efficiency values under each of the revised models. The differences between the original and revised single group analysis models is summarised in the table below.

Table 3-3 - Single Group Original and Revised Model Results

Model	Local Government Group	Mean Technical Efficiency		Standard Deviation of Technical Efficiency		On the frontier	
		CRS	VRS	CRS	VRS	CRS	VRS
Original 1	Single Group	0.74	0.81	0.16	0.15	9	20
Revised 1	Single Group	0.74	0.80	0.15	0.14	7	14
Original 2	Single Group	0.71	0.79	0.17	0.16	6	17
Revised 2	Single Group	0.68	0.76	0.16	0.16	4	11
Original 3	Single Group	0.76	0.83	0.16	0.15	11	23
Revised 3	Single Group	0.72	0.72	0.15	0.15	6	14

Model	Local Government Group	Mean Technical Efficiency		Standard Deviation of Technical Efficiency		On the frontier	
		CRS	VRS	CRS	VRS	CRS	VRS
Original 4	Single Group	0.73	0.81	0.16	0.15	6	18
Revised 4	Single Group	0.71	0.78	0.15	0.15	3	12
Original 5	Single Group	0.76	0.82	0.15	0.14	6	15
Revised 5	Single Group	0.71	0.78	0.15	0.15	3	12

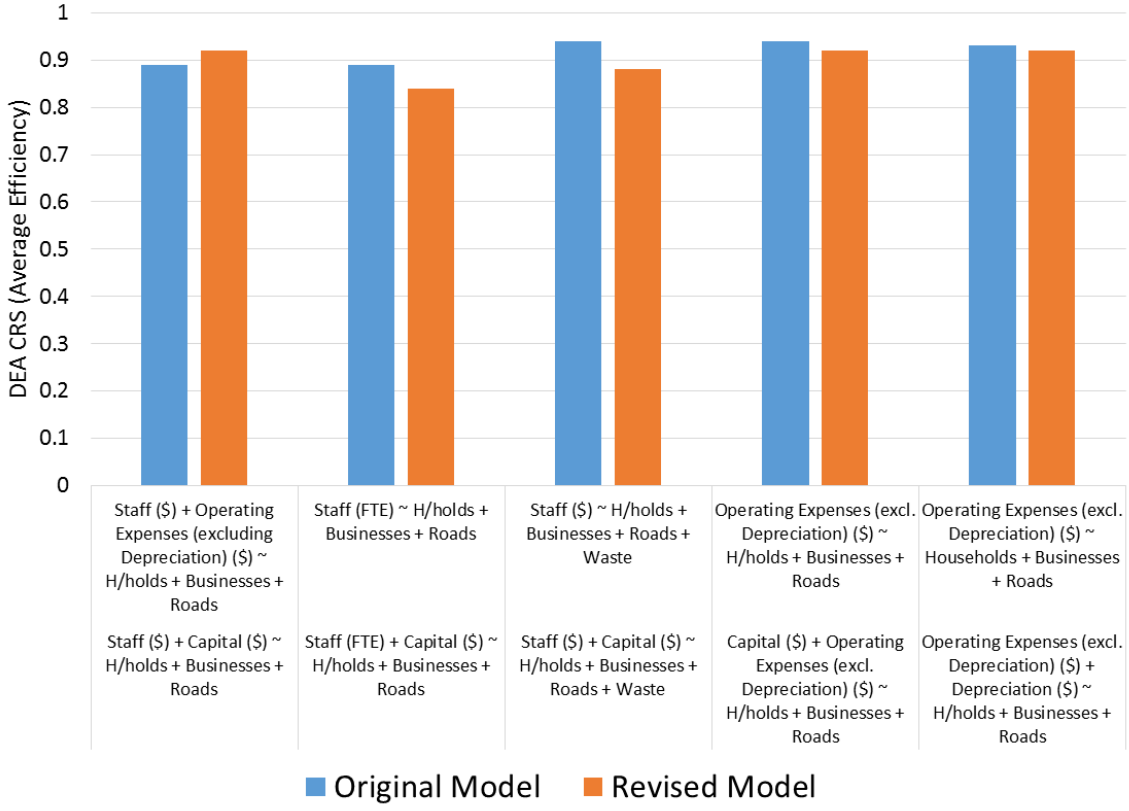
3.3 DEA Multiple Group Result Comparison

This section outlines differences between the original and revised models at the multiple group level (i.e. Interface, Large Rural, Metropolitan, Regional Centre and Small Rural) across the five models. The results presented in this section are the averages of all local governments in their particular grouping and do not represent each local government's performance on an individual level.

Interface Group of Municipalities

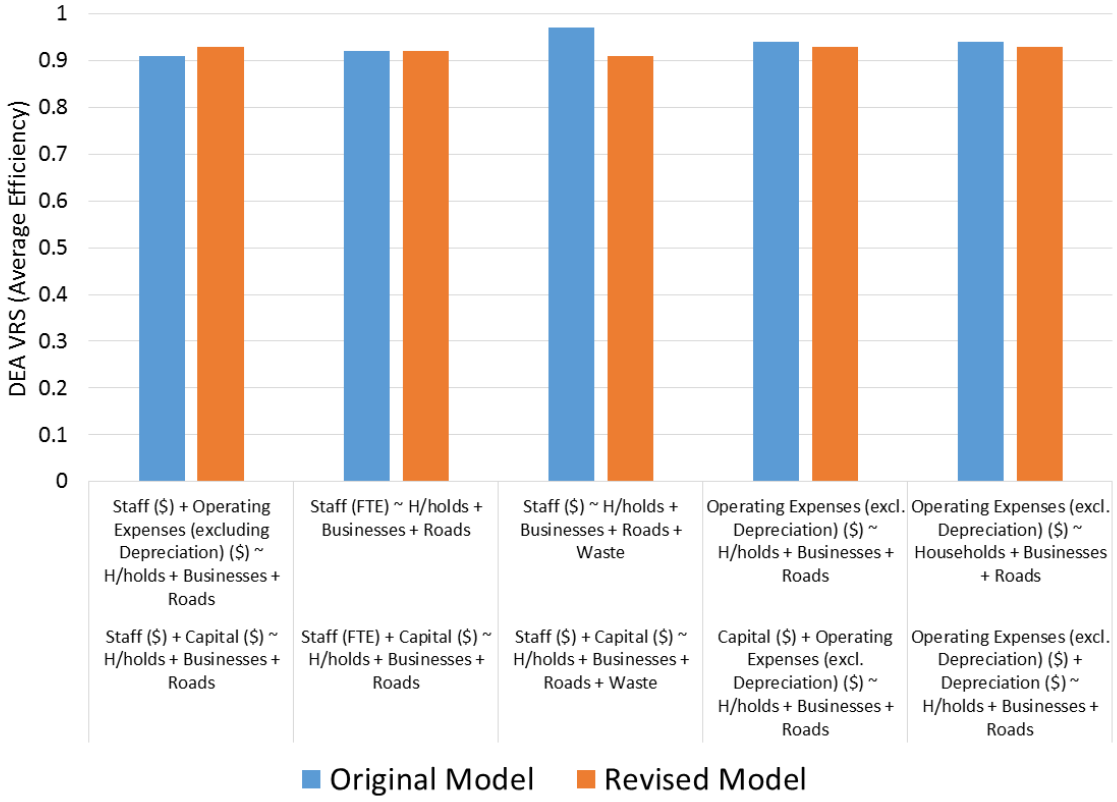
This subsection compares the model results across the Interface group of municipalities. The chart below shows the difference between the average CRS of the original and revised models.

Figure 3-3 - Interface Group Original and Revised CRS Averages



The greatest difference in CRS averages for the Interface group is between the original and revised Model 3, with the revised model's average 0.06 (6%) lower than the original's. As the largest difference between the models is 6%, the differences between them should not be considered statistically significant. The chart below shows the difference between the average VRS of the original and revised models for the Interface group of municipalities.

Figure 3-4 - Interface Group Original and Revised VRS Averages



The figure above indicates that the greatest difference in VRS averages lies between the original and revised Model 3. As the revised Model 3 average is 0.06 (6%) lower than the original's little variation seems to exist. It should be noted that as the largest difference between the models is 6%, the differences between them should not be considered statistically significant. A full comparison of the original and revised models for the Interface municipalities is detailed below.

Table 3-4 - DEA Mean Technical Efficiencies for the 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
Original 1	Interface	0.89	0.91	0.14	0.14	3	6
Revised 1	Interface	0.92	0.93	0.11	0.11	5	6
Original 2	Interface	0.89	0.92	0.13	0.12	4	6
Revised 2	Interface	0.84	0.92	0.14	0.13	1	5
Original 3	Interface	0.94	0.97	0.10	0.08	4	7
Revised 3	Interface	0.88	0.91	0.12	0.13	3	6

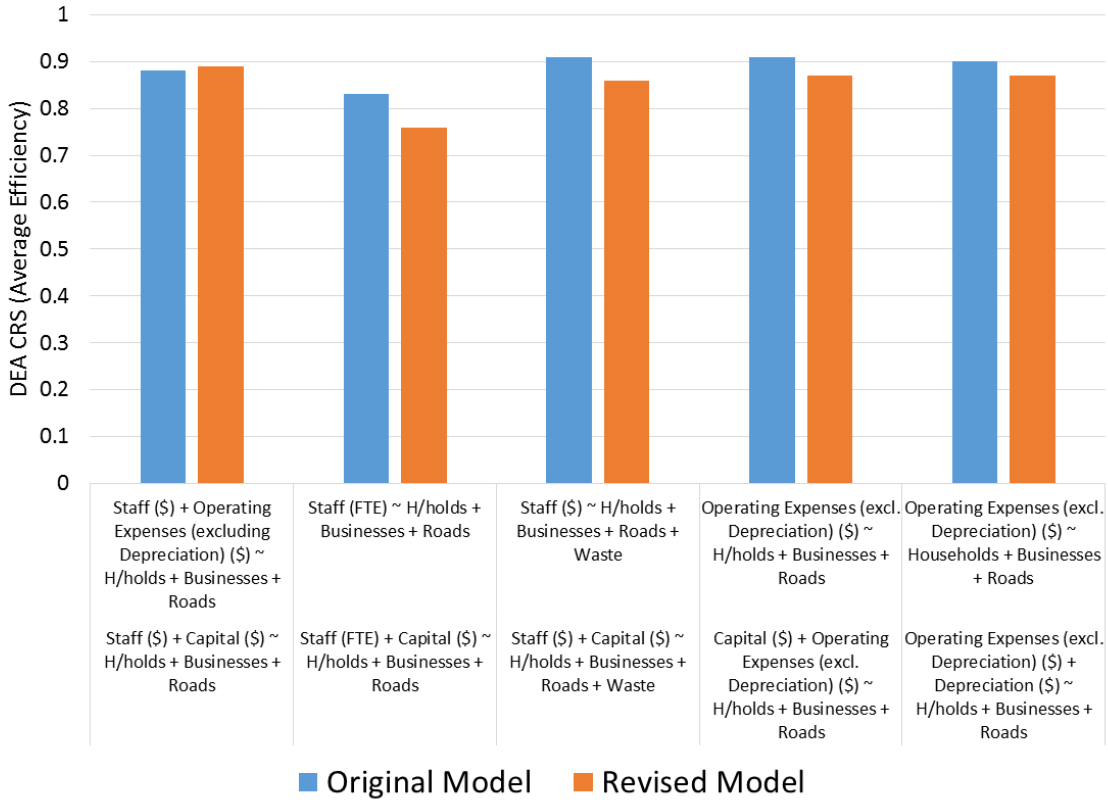
Model	Local Government Group	Mean Technical Efficiency		Standard Deviation of Technical Efficiency		On the frontier	
		CRS	VRS	CRS	VRS	CRS	VRS
Original 4	Interface	0.94	0.94	0.11	0.11	6	8
Revised 4	Interface	0.92	0.93	0.11	0.11	4	5
Original 5	Interface	0.93	0.94	0.11	0.11	4	6
Revised 5	Interface	0.92	0.93	0.11	0.11	4	5

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

Large Rural Group of Municipalities

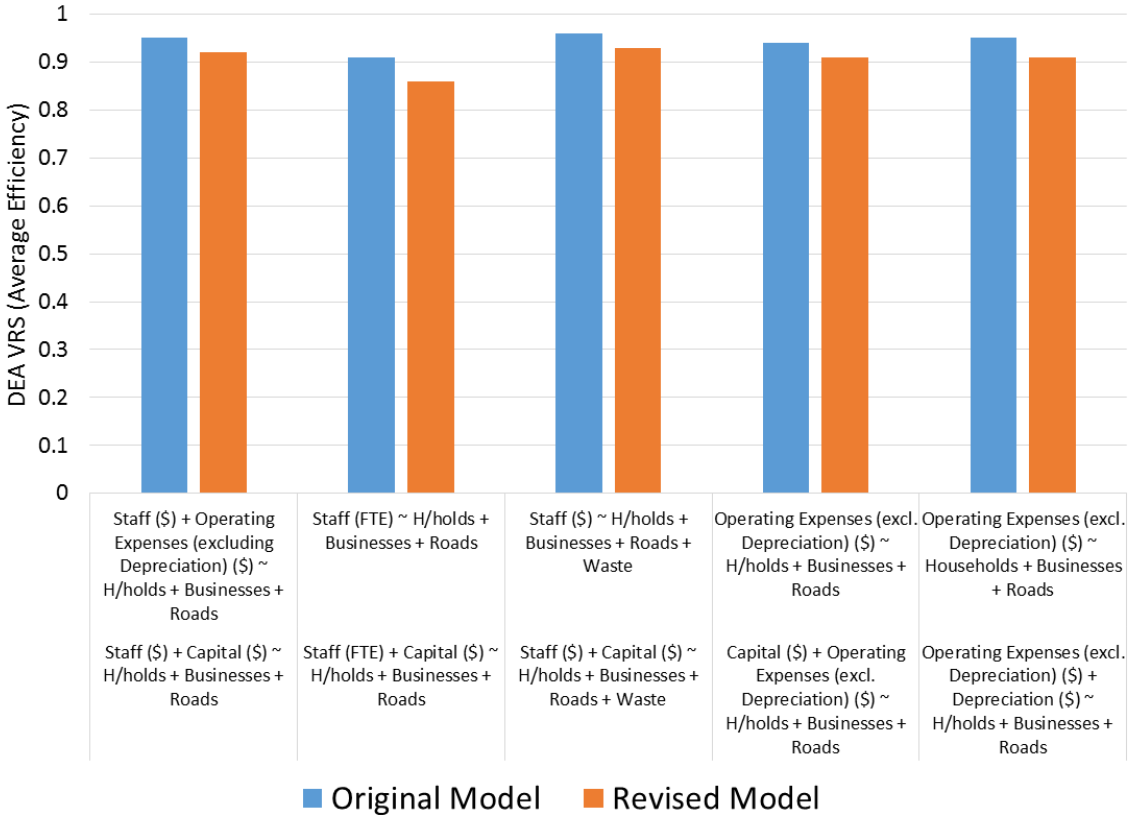
This subsection compares model results across the Large Rural group of municipalities. Figure 3-5 below shows the difference between the CRS averages of the original and revised models across the Large Rural group of municipalities.

Figure 3-5 - Large Rural Original and Revised CRS Averages



The figure above indicates that the greatest difference in CRS averages lies between the original and revised Model 2. As the revised Model 2 average is 0.07 (7%) lower than the original's, the variation between the models should not be considered statistically significant. The chart below shows the differences between the original and revised average VRS for the Large Rural group of municipalities.

Figure 3-6 - Large Rural Original and Revised VRS Averages



The figure above indicates the greatest difference in VRS averages for the Large Rural group is between the original and revised Model 2, with the revised model's average 0.05 (5%) lower than the original's. It should be noted that as the greatest difference is only 5%, the differences between the models should not be considered statistically significant. A full comparison of the original and revised models for the Large Rural municipalities is tabled below.

Table 3-5 - DEA Mean Technical Efficiencies for the Large Rural Group of Local Governments

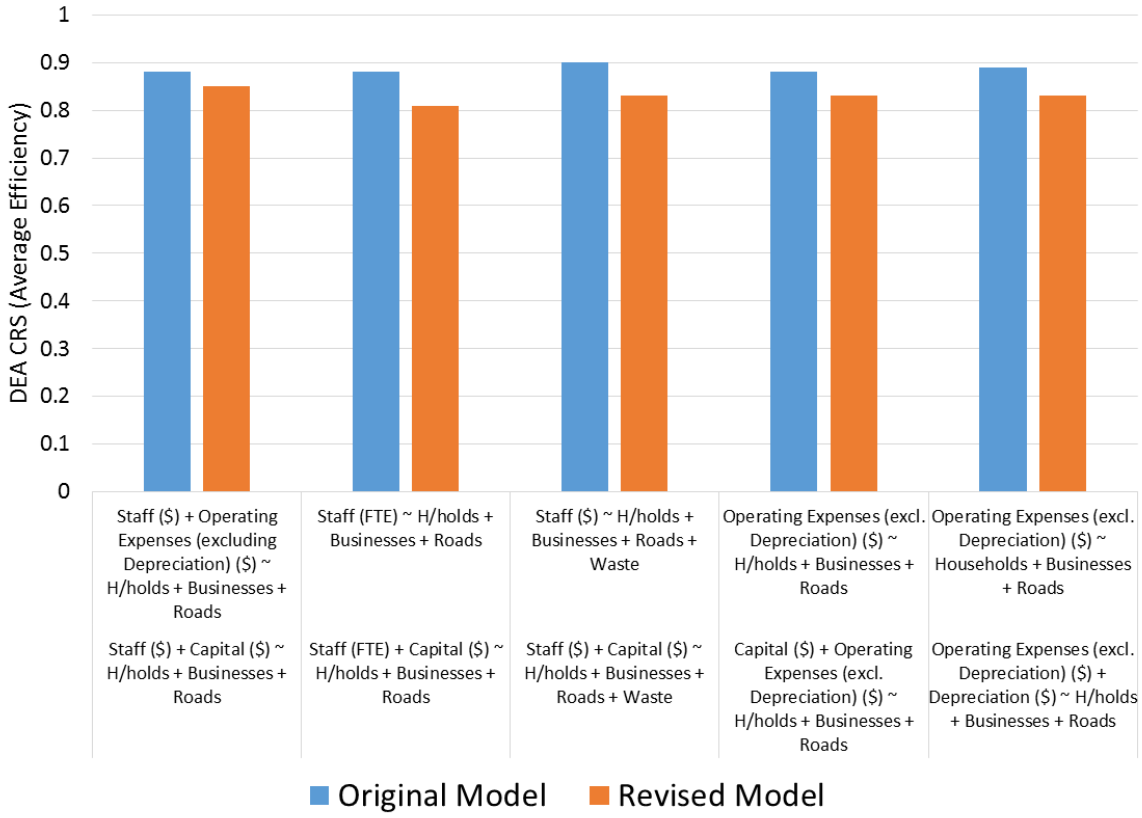
Model	Local Government Group	Mean Technical Efficiency		Standard Deviation of Technical Efficiency		On the frontier	
		CRS	VRS	CRS	VRS	CRS	VRS
Original 1	Large Rural	0.88	0.95	0.11	0.07	3	10
Revised 1	Large Rural	0.89	0.92	0.12	0.10	4	9
Original 2	Large Rural	0.83	0.91	0.13	0.09	3	8
Revised 2	Large Rural	0.76	0.86	0.14	0.12	2	5
Original 3	Large Rural	0.91	0.96	0.09	0.06	3	12
Revised 3	Large Rural	0.86	0.93	0.11	0.09	2	10

Model	Local Government Group	Mean Technical Efficiency		Standard Deviation of Technical Efficiency		On the frontier	
		CRS	VRS	CRS	VRS	CRS	VRS
Original 4	Large Rural	0.91	0.94	0.10	0.09	6	10
Revised 4	Large Rural	0.87	0.91	0.12	0.11	4	8
Original 5	Large Rural	0.90	0.95	0.10	0.08	6	11
Revised 5	Large Rural	0.87	0.91	0.12	0.11	4	8

Metropolitan Group of Municipalities

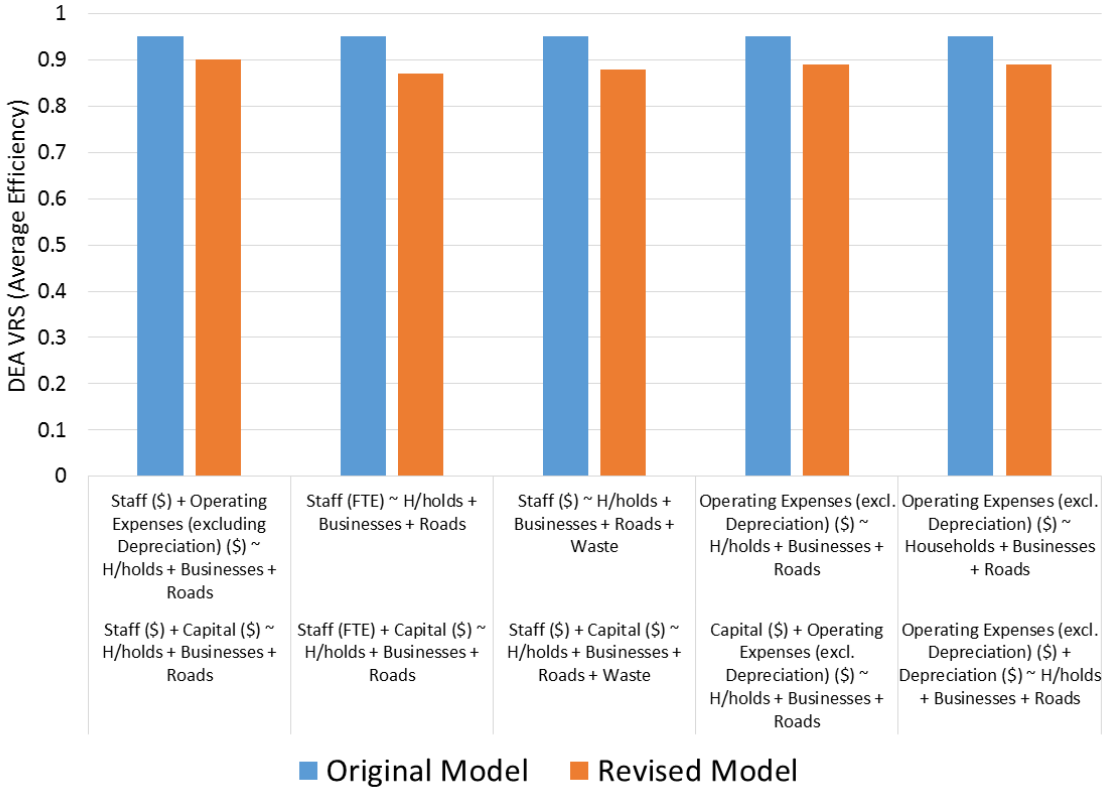
This subsection compares model results across the Metropolitan group of municipalities. The chart below depicts the difference between the average CRS of the original and revised models across the Metropolitan group of municipalities.

Figure 3-7 - Metropolitan Original and Revised CRS Averages



The chart indicates the greatest difference in CRS averages for the Metropolitan group is between the original and revised Models 2 and 3, with the average of the revised models 0.07 (7%) lower than the original's in both cases. As the largest difference between the models is only 7%, the differences between them should not be considered statistically significant. The chart below compares the results of the average VRS of the original and revised models.

Figure 3-8 - Metropolitan Original and Revised VRS Averages



The figure above indicates that the greatest difference in VRS averages lies between the original and revised Model 2. As the revised Model 2 average is 0.08 (8%) lower than the original's, little variation seems to exist. Due to the fact the largest difference between the models is only 5%, the differences between them should not be considered statistically significant. A full comparison of the original and revised models for the Metropolitan municipalities is detailed below.

Table 3-6 - DEA Mean Technical Efficiencies for the Metropolitan Group of Local Governments

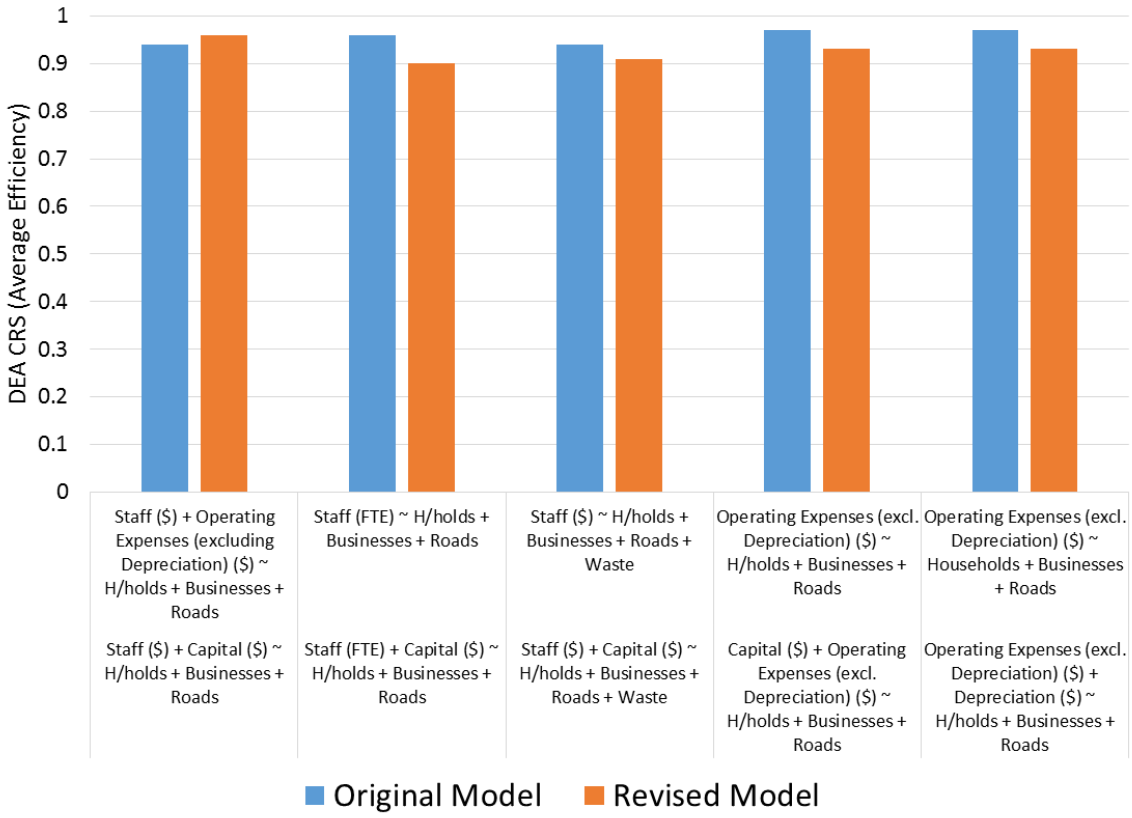
Model	Local Government Group	Mean Technical Efficiency		Standard Deviation of Technical Efficiency		On the frontier	
		CRS	VRS	CRS	VRS	CRS	VRS
Original 1	Metropolitan	0.88	0.95	0.14	0.08	6	11
Revised 1	Metropolitan	0.85	0.90	0.15	0.10	4	7
Original 2	Metropolitan	0.88	0.95	0.14	0.08	5	12
Revised 2	Metropolitan	0.81	0.87	0.15	0.13	3	7
Original 3	Metropolitan	0.90	0.95	0.13	0.07	8	11
Revised 3	Metropolitan	0.83	0.88	0.15	0.12	4	6
Original 4	Metropolitan	0.88	0.95	0.14	0.07	6	12

Model	Local Government Group	Mean Technical Efficiency		Standard Deviation of Technical Efficiency		On the frontier	
		CRS	VRS	CRS	VRS	CRS	VRS
Revised 4	Metropolitan	0.83	0.89	0.15	0.11	3	7
Original 5	Metropolitan	0.89	0.95	0.13	0.06	6	9
Revised 5	Metropolitan	0.83	0.89	0.15	0.11	3	7

Regional Centre Group of Municipalities

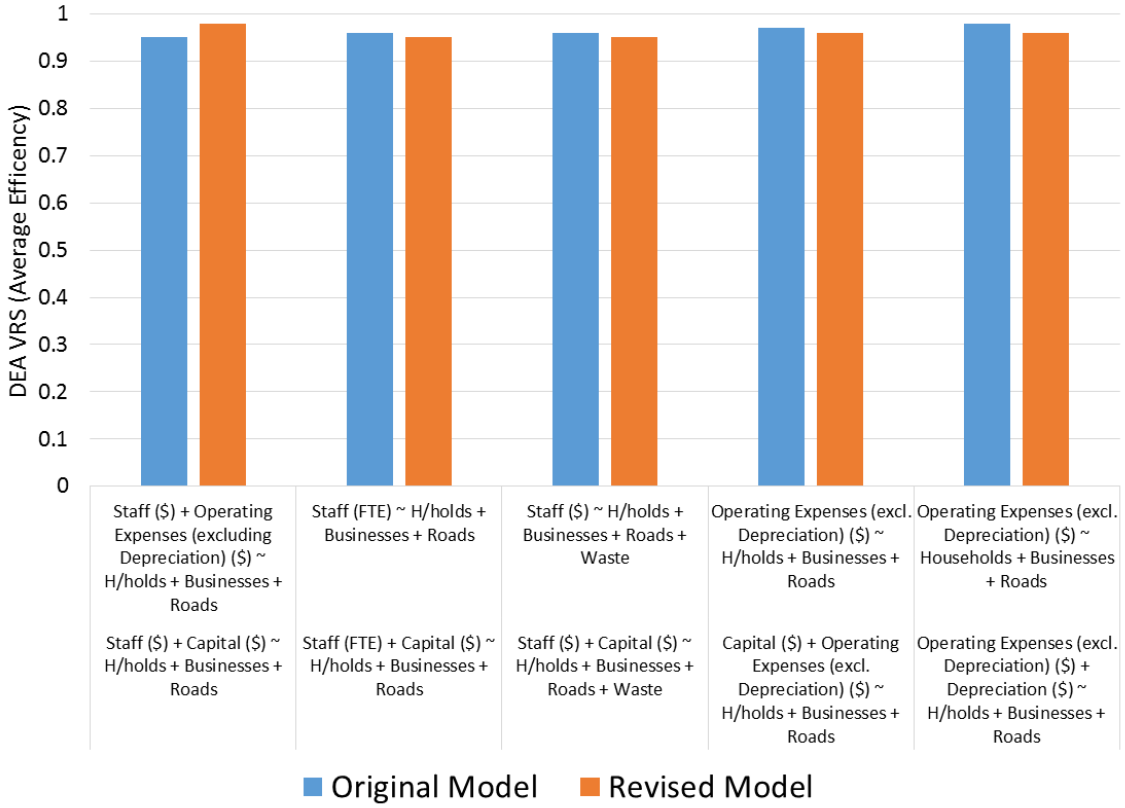
This subsection compares model results across the Regional Centre group of municipalities. The chart below shows the difference between the original and revised models CRS averages for the Regional Centre group of municipalities.

Figure 3-9 - Regional Centre Original and Revised CRS Averages



The figure above indicates that the greatest difference in CRS averages lies between the original and revised Model 2. As the largest difference between models is 6%, the differences between them should not be considered statistically significant. The chart below shows the differences between the original and revised model's average VRS for the Regional Centre group of municipalities.

Figure 3-10 - Regional Centre Original and Revised VRS Averages



The figure above indicates the greatest difference in VRS averages for the Regional Centre group is between the original and revised Model 1 with the revised model's average 0.03 (3%) higher than the original's. As the greatest difference between the models is 3%, the differences between them should not be considered statistically significant. A detailed comparison of the original and revised models for the Regional Centre group of municipalities is detailed below.

Table 3-7 - DEA Mean Technical Efficiencies for the Regional Centre Group of Local Governments

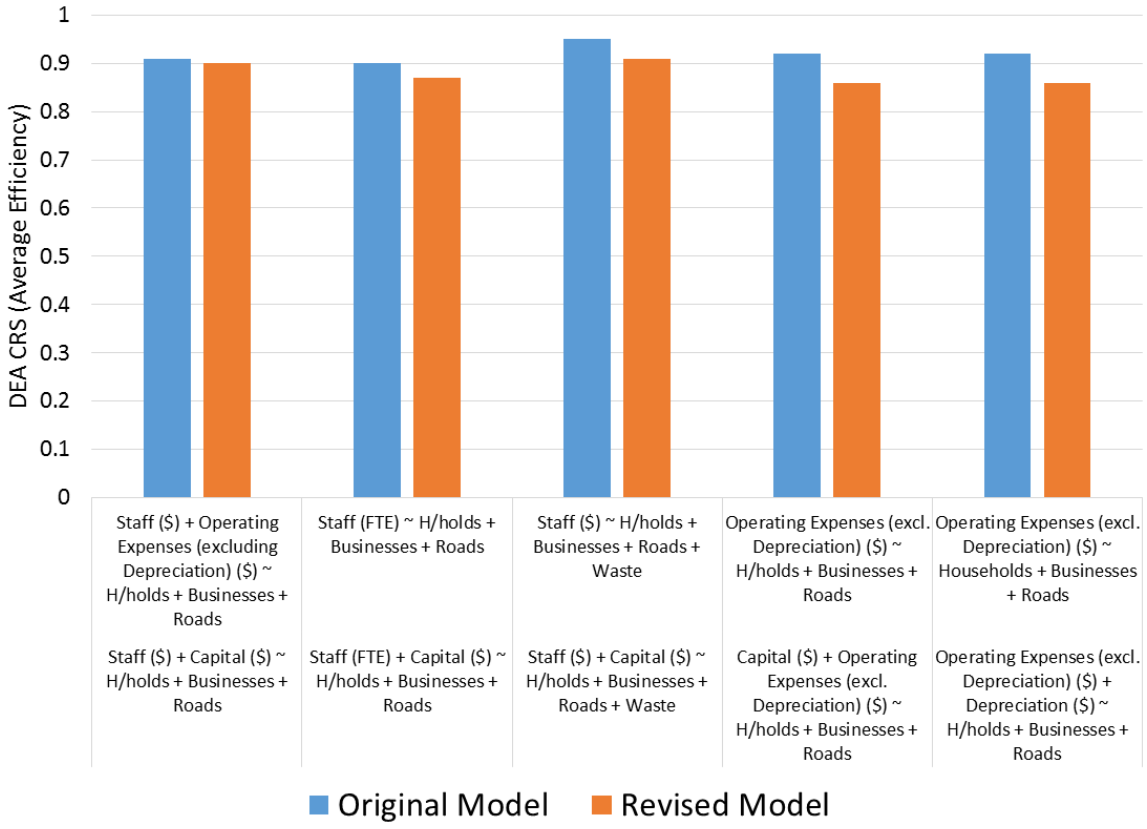
Model	Local Government Group	Mean Technical Efficiency		Standard Deviation of Technical Efficiency		On the frontier	
		CRS	VRS	CRS	VRS	CRS	VRS
Original 1	Regional Centre	0.94	0.95	0.09	0.09	6	7
Revised 1	Regional Centre	0.96	0.98	0.09	0.07	6	8
Original 2	Regional Centre	0.96	0.96	0.09	0.09	7	8
Revised 2	Regional Centre	0.90	0.95	0.13	0.12	2	7
Original 3	Regional Centre	0.94	0.96	0.09	0.07	6	7

Model	Local Government Group	Mean Technical Efficiency		Standard Deviation of Technical Efficiency		On the frontier	
		CRS	VRS	CRS	VRS	CRS	VRS
Revised 3	Regional Centre	0.91	0.95	0.11	0.10	4	7
Original 4	Regional Centre	0.97	0.97	0.06	0.06	7	8
Revised 4	Regional Centre	0.93	0.96	0.10	0.07	4	6
Original 5	Regional Centre	0.97	0.98	0.04	0.04	5	7
Revised 5	Regional Centre	0.93	0.96	0.10	0.07	4	6

Small Rural Group of Municipalities

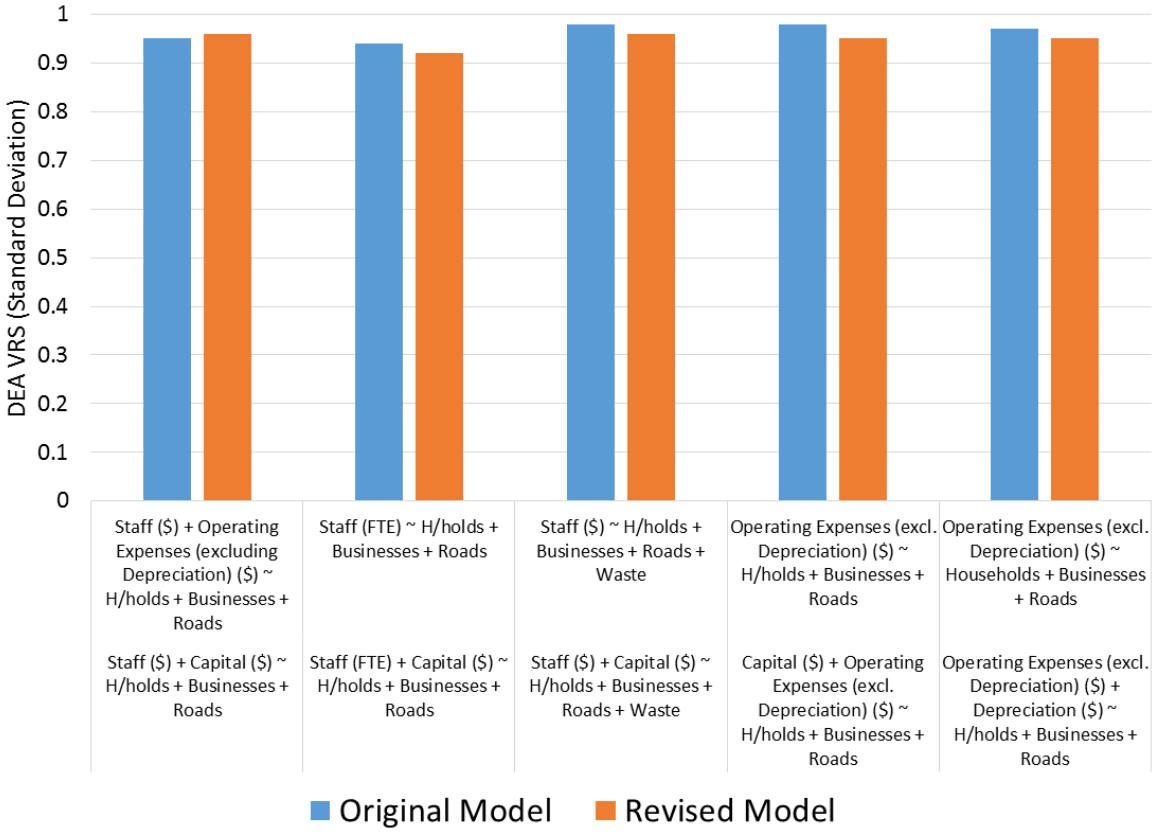
This subsection details the results of a comparison between the models for the Small Rural group of municipalities. The chart below depicts the differences between the original and revised average CRS for the Small Rural group of municipalities.

Figure 3-11 - Small Rural Original and Revised CRS Averages



The figure above indicates the greatest difference in CRS averages for the Small Rural group is between the original and revised Models 4 and 5, with the revised model's CRS average 0.06 (6%) lower than the original's in both cases. As the greatest difference between the models is 6%, the differences between them should not be considered statistically significant. The chart below depicts the difference between the average VRS of the original and revised models for the Small Rural group of municipalities.

Figure 3-12 - Small Rural Original and Revised VRS Averages



The figure above indicates that the greatest difference in VRS averages lies between the original and revised Model 4. As the revised Model 4 average is 0.03 (3%) lower than the original's, little variation seems to exist. As the greatest difference between the original and revised models is 3%, the differences between them should not be considered statistically significant. A full comparison of the original and revised models for the Small Rural municipalities is detailed below.

Table 3-8 - 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
Original 1	Small Rural	0.91	0.95	0.10	0.07	8	11
Revised 1	Small Rural	0.90	0.96	0.10	0.05	5	9
Original 2	Small Rural	0.90	0.94	0.11	0.09	8	11
Revised 2	Small Rural	0.87	0.92	0.12	0.10	4	9
Original 3	Small Rural	0.95	0.98	0.07	0.04	8	15
Revised 3	Small Rural	0.91	0.96	0.09	0.06	5	12

Model	Local Government Group	Mean Technical Efficiency		Standard Deviation of Technical Efficiency		On the frontier	
		CRS	VRS	CRS	VRS	CRS	VRS
Original 4	Small Rural	0.92	0.98	0.10	0.05	7	12
Revised 4	Small Rural	0.86	0.95	0.11	0.06	4	8
Original 5	Small Rural	0.92	0.97	0.08	0.05	8	11
Revised 5	Small Rural	0.86	0.95	0.11	0.06	4	8

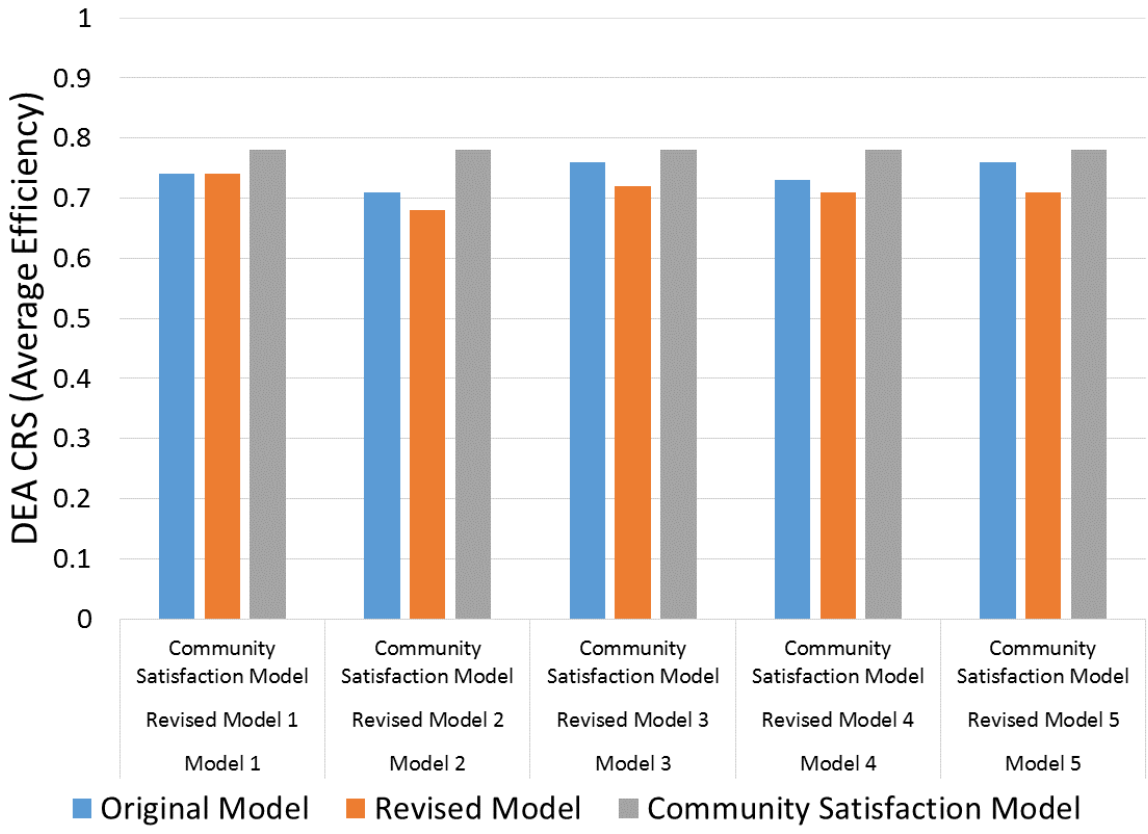
4 Community Satisfaction DEA Model

A community satisfaction DEA model was prepared (using data from the Local Government Community Satisfaction Survey published by the Department of Environment, Land, Water and Planning) to account for community satisfaction when measuring productivity. The model has the same specification as the revised Model 1, however the council's community satisfaction results (overall result on a multiple group level e.g. all Interface councils received the overall Interface score) have been included as an additional output. The community satisfaction DEA specification has been outlined below.

Community Satisfaction Model:	*Staff ($) + Operating Expenses (excluding Depreciation and Staff) ($) = H/holds + Businesses + Roads + Council Group's Overall Satisfaction Score*

The chart below shows a comparison between the CRS averages of the community satisfaction DEA and the original and revised models at the single group level.

Figure 4-1 - Single Group CRS Averages of the Original, Revised and Community Satisfaction DEA Models

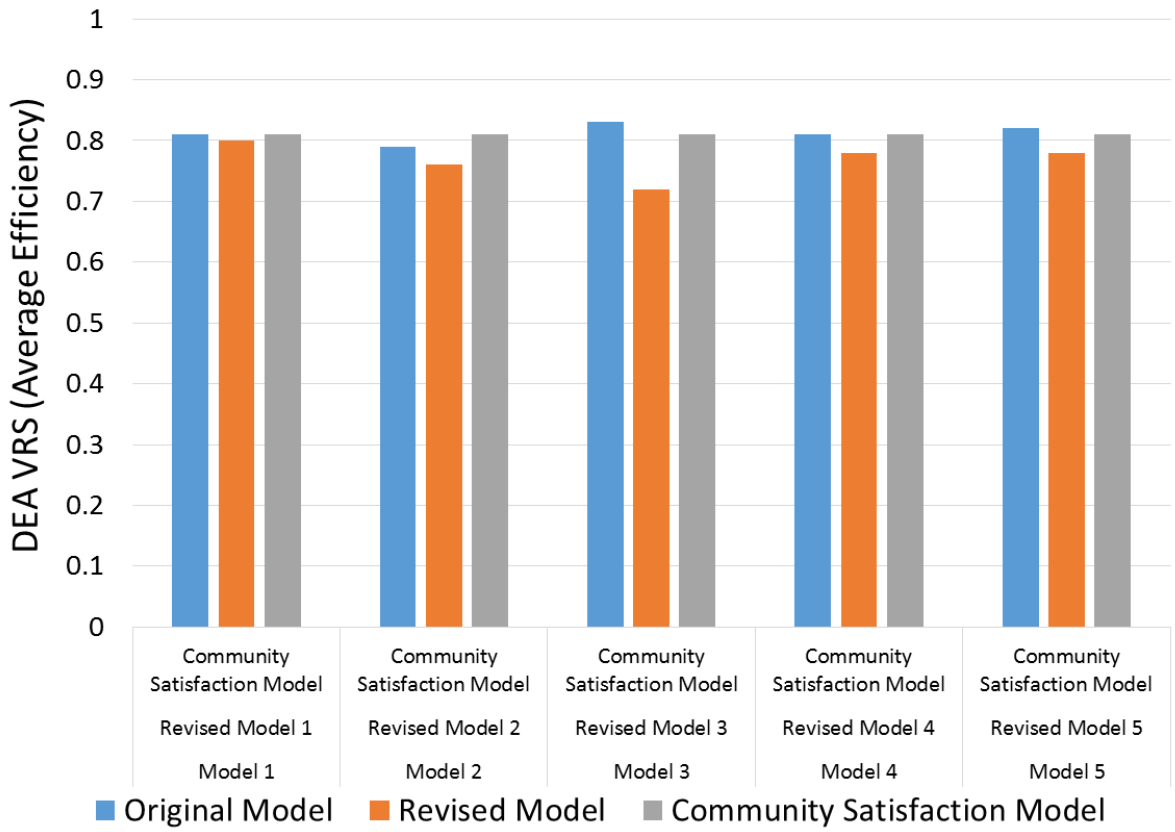


According to Figure 4-1, the greatest difference across the original models lies between the community satisfaction model and the original Model 2. The average CRS of the community satisfaction model is 0.07 (7%) higher than that of the original Model 2.

Of the revised models, the difference between the community satisfaction model and the revised Model 2 is the largest as the CRS average of the community satisfaction

model is 0.10 (10%) larger than that of the revised Model 2. As the greatest difference between the community satisfaction and the original and revised models is 10%, the differences between the models should not be considered statistically significant. Figure 4-2 below compares the average VRS of the community satisfaction model and the original and revised models.

Figure 4-2 - Single Group VRS Averages of the Original, Revised and Community Satisfaction DEA Models



The figure above indicates that the greatest difference across the original models is between the community satisfaction model and the original Models 2 and 3, with both models differing by approximately 0.02 (2%) from the community satisfaction model.

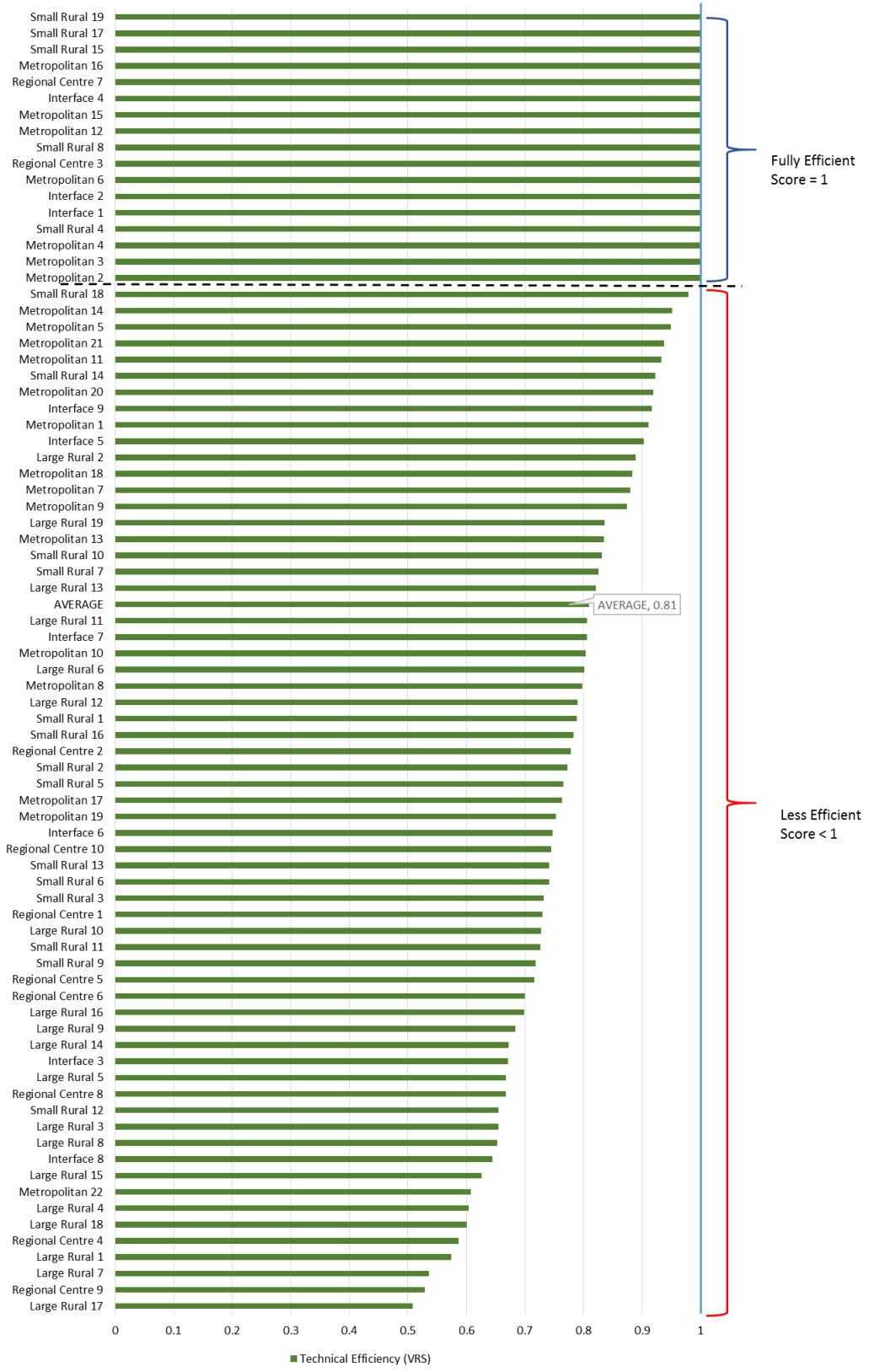
The greatest difference between the community satisfaction and the revised models is between the community satisfaction model and the revised Model 3, where the community satisfaction model VRS average is 0.09 (9%) higher than that of the revised Model 3. As the greatest difference between the original and revised models and the community satisfaction model is 9%, the differences between the models should not be considered statistically significant. The single group results of the community satisfaction DEA have been summarised in the table below.

Table 4-1 - Community Satisfaction DEA Single Group Analysis Results

Model	Local Government Group	Mean Technical Efficiency		Standard Deviation of Technical Efficiency		On the frontier	
		CRS	VRS	CRS	VRS	CRS	VRS
Community Satisfaction	Single Group	0.78	0.81	0.14	0.14	10	17

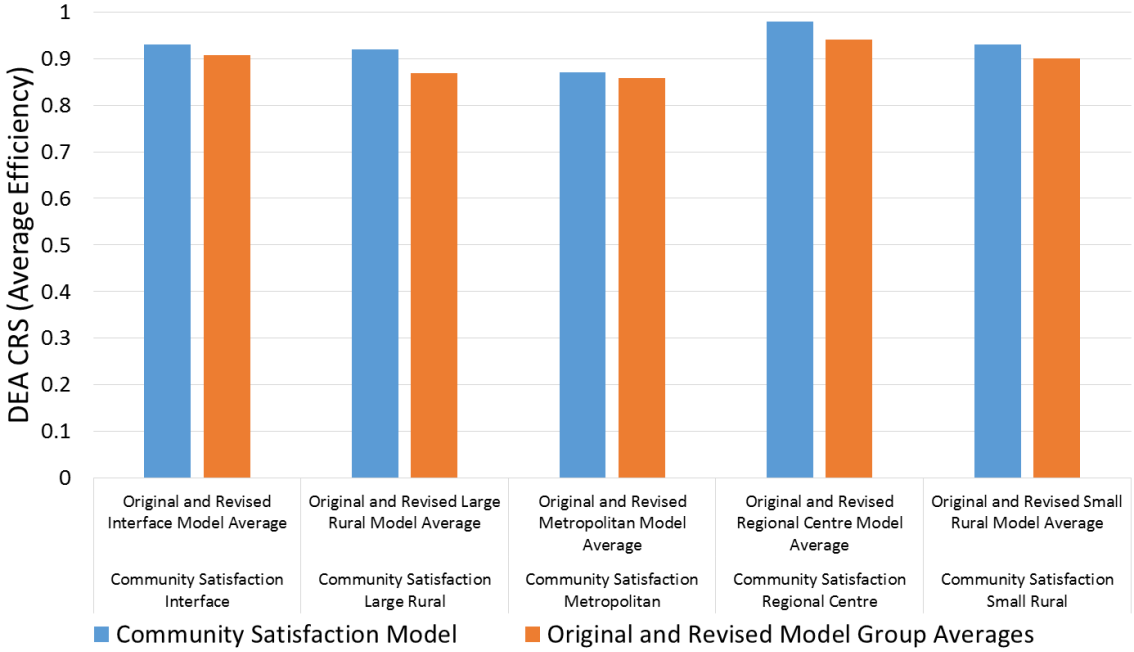
The chart below depicts the council efficiency rankings after including satisfaction as an output.

Figure 4-3 - Council Efficiency Rankings after the Inclusion of Community Satisfaction as an Output



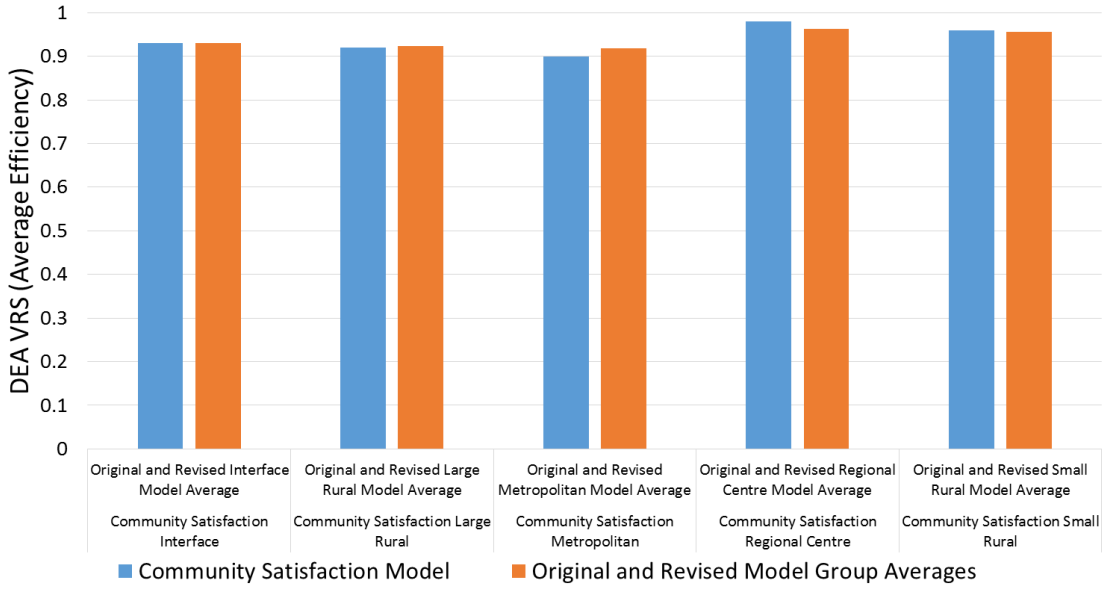
The chart below depicts the difference between the average CRS of the community satisfaction model and the combined average of the original and revised models at the multiple group level.

Figure 4-4 - Multiple Group Community Satisfaction and Combined Original and Revised Model CRS Averages



According to Figure 4-4, the greatest difference exists between the average CRS of the community satisfaction model and the combined average of the revised and original models of the Large Rural group of municipalities. For these councils, the community satisfaction CRS average is 0.052 (5.2%) greater than the combined average of the original and revised Large Rural models. As the greatest difference between the community satisfaction model's average and the average of the original and revised models is 5.2%, the variation should not be considered statistically significant. The chart below shows the difference between the average VRS of the community satisfaction model and the combined average of the original and revised models at the multiple group level.

Figure 4-5 - Multiple Group Community Satisfaction and Combined Original and Revised Model VRS Averages



The above figure shows that the greatest difference lies between the average VRS of the community satisfaction model and the combined average of the revised and original models for the Metropolitan and Regional Centre group of municipalities. For these groups, the community satisfaction VRS average differs by 0.018 (1.8%). As the greatest difference between the community satisfaction model's average and the average of the original and revised models is 1.8%, the variation should not be considered statistically significant. The results at the multiple group level are summarised in the table below.

Table 4-2 – Community Satisfaction DEA Results at the Local Government Group Level

Local Government Group	Mean Technical Efficiency		Standard Deviation of Technical Efficiency		On the frontier	
	CRS	VRS	CRS	VRS	CRS	VRS
Interface	0.93	0.93	0.11	0.11	5	6
Large Rural	0.92	0.92	0.10	0.10	7	9
Metropolitan	0.87	0.90	0.13	0.10	4	7
Regional Centre	0.98	0.98	0.07	0.07	7	8
Small Rural	0.93	0.96	0.07	0.05	7	9

Overall, only minimal differences were found between the models that included and did not include community satisfaction as an output. This finding is consistent with the existing academic literature.[5]

[5] For example, consider: Kim Woodbury and Brian Dollery, "Efficiency Measurement in Australian Local Government: The Case of NSW Municipal Water Services," *Working Paper Series in Economics* 2003-13 (2003): 36.

5 Service Level DEA Model Results

This section details the results of the three service level DEA models. These models are:

- a shared input DEA model using roads and waste data;
- a shared input DEA model using LGPRF data; and
- a waste management DEA model.

A comparison to the five original and revised models is also provided.

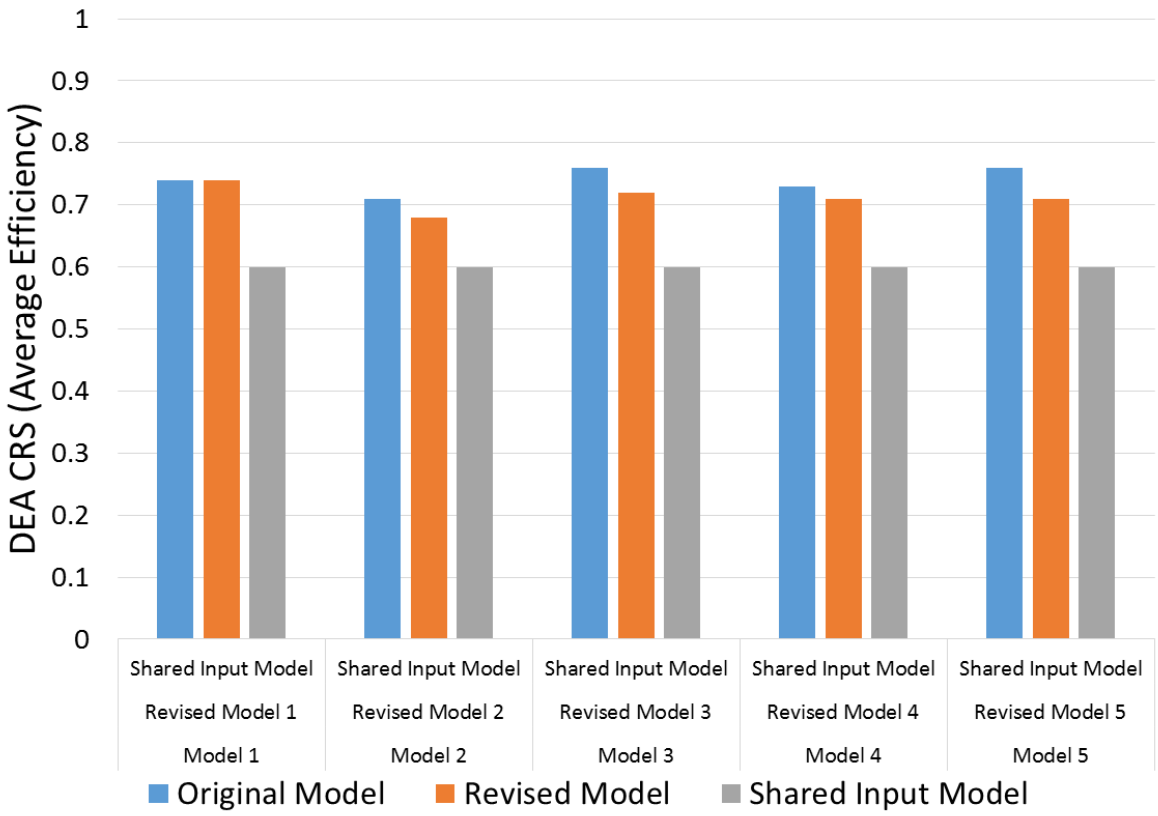
5.1 Shared Input DEA

A shared input DEA model was developed using operating expenses as the sole input and the total tonnage of garbage collected and the total length of sealed and unsealed roads as the output. The purpose of the shared input DEA is to calculate the efficiency of the councils at the service level (in this case the provision of garbage collection services and roads). The shared input DEA specification has been summarised below.

Shared Input Model:	*Operating Expenses (excluding Depreciation) ($) = Roads (Kms) + Garbage Collected (Tonnes)*

The chart below shows a comparison between the CRS averages of the shared input DEA and the original and revised models at the single group level.

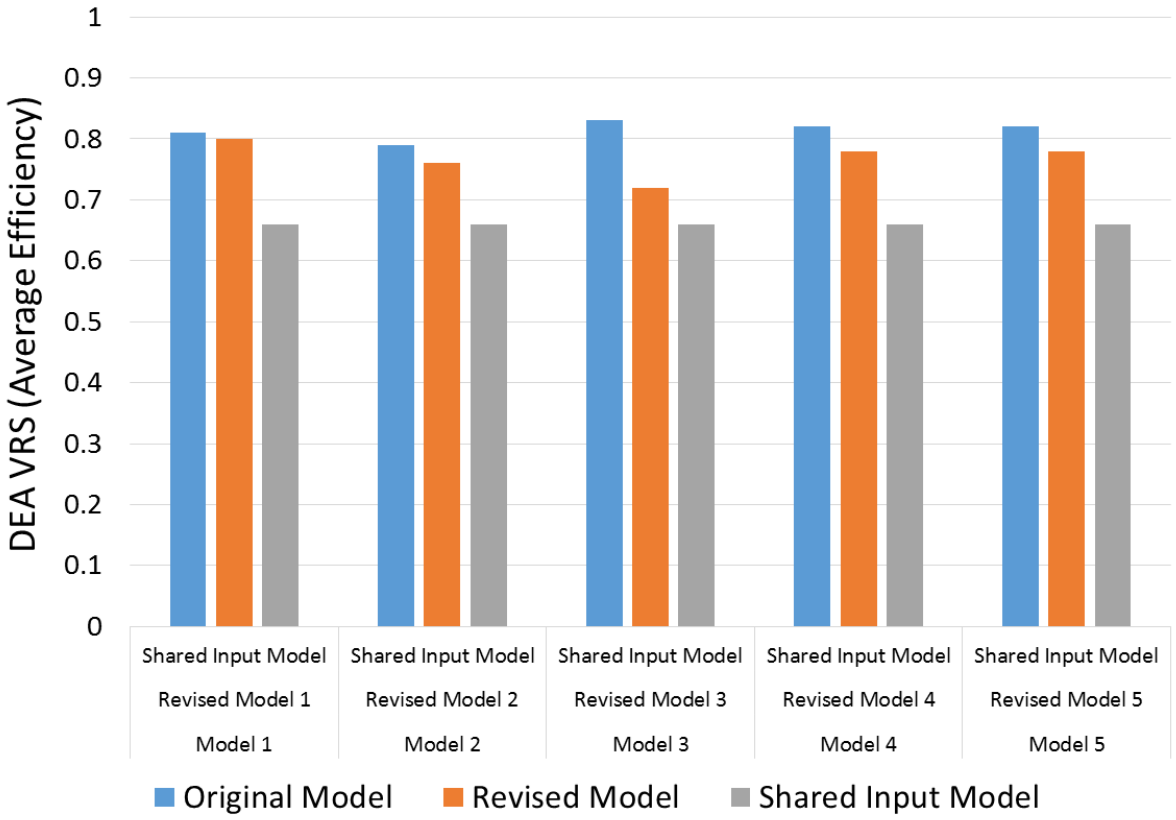
Figure 5-1 - Single Group CRS Averages of the Original, Revised and Shared Input DEA Models



The figure above indicates that the greatest difference across the original models is between the shared input model and the original models 3 and 5. The average CRS of the shared input model is 0.16 (16%) lower than that of the original models 3 and 5.

The greatest difference between the shared input and the revised models is between the shared input model and Model 1, where the shared input CRS average is 0.14 (14%) lower than that of the revised Model 1. Although the largest difference between the shared input model and the original and revised models is 16%, it should be noted the municipalities had on average, comparatively lower efficiency scores under the shared input model. The figure below depicts differences between the average VRS of the original, revised and shared input models.

Figure 5-2 - Single Group VRS Averages of the Original, Revised and Shared Input DEA Models



The figure above indicates that the greatest difference across the original models is between the shared input model and the original Model 3. The average VRS of the shared input model is 0.17 (17%) lower than that of the original Model 3.

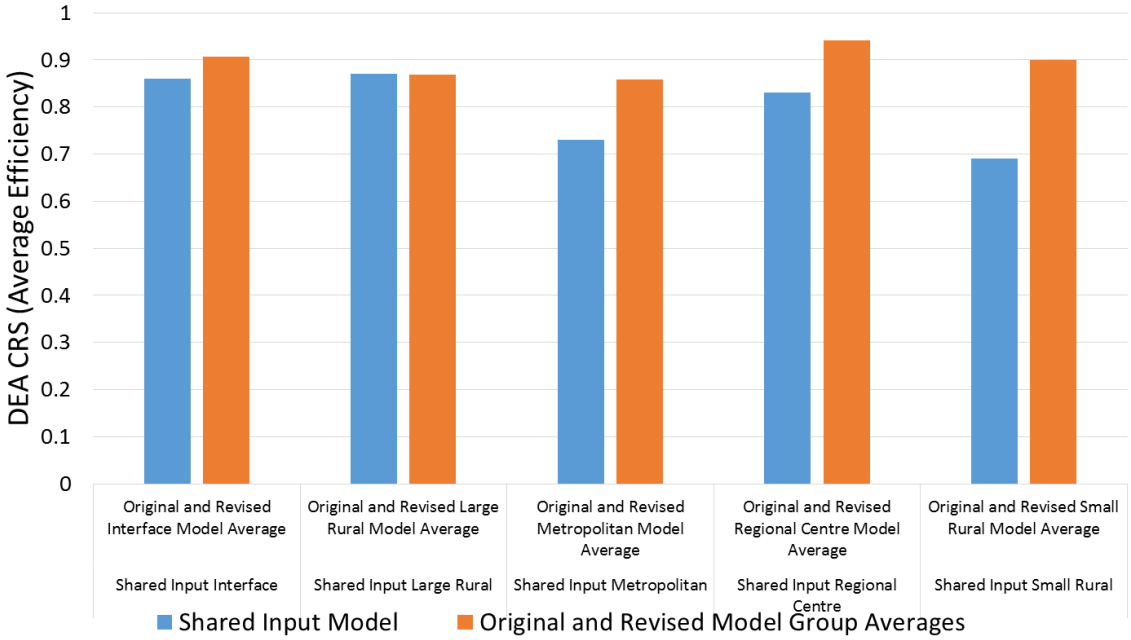
The greatest difference between the shared input and the revised models is between the shared input and revised Model 1, where the shared input VRS average is 0.14 (14%) lower than that of the revised Model 1. Although the largest difference between the shared input model and the original and revised models is 17%, it should be noted the municipalities had on average, comparatively lower efficiency scores under the shared input model. The single group results of the shared input DEA have been summarised in the table below.

Table 5-1 - Shared Input DEA Single Group Analysis Results

Model	Local Government Group	Mean Technical Efficiency		Standard Deviation of Technical Efficiency		On the frontier	
		CRS	VRS	CRS	VRS	CRS	VRS
Shared Input	Single Group	0.60	0.66	0.19	0.19	2	7

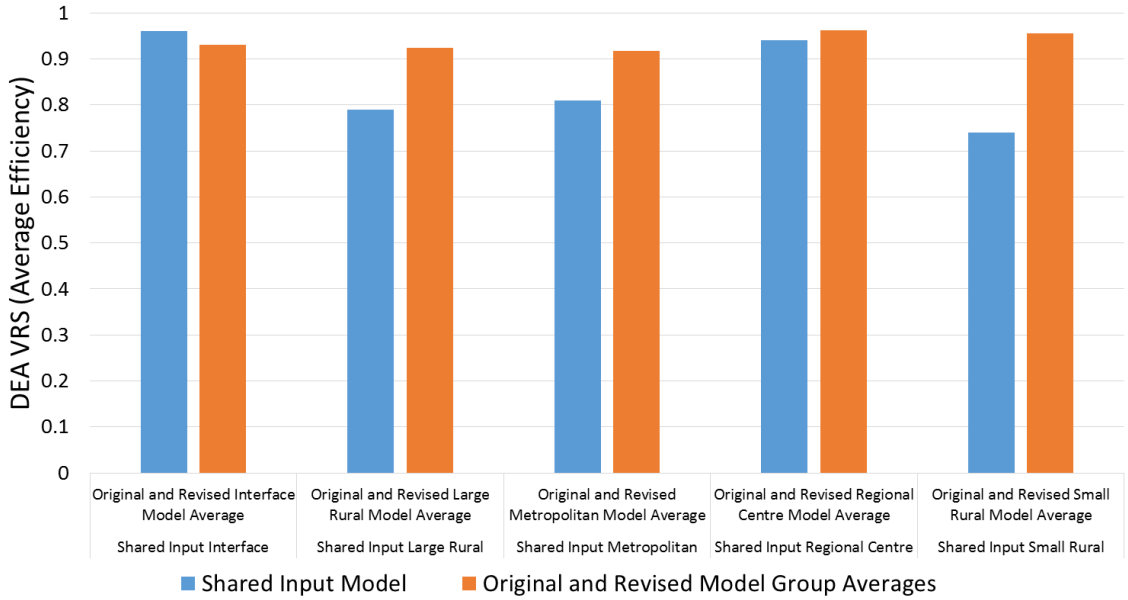
The chart below depicts the difference between the average CRS of the shared input model and the combined average of the original and revised models at the multiple group level.

Figure 5-3 - Multiple Group Shared Input and Combined Original and Revised Model CRS Averages



The above chart shows that the greatest difference lies between the average CRS of the shared input model and the combined average of the revised and original models of the Metropolitan group of municipalities. For these council's, the shared input CRS average is 0.128 (12.8%) lower than the average of the original and revised Metropolitan models. Although the largest difference between averages is 12.8%, we note that the Metropolitan municipalities had on average, comparatively lower efficiencies under the shared input model, as did all but the Large Rural group of municipalities. The chart below shows the difference between the average VRS of the shared input model and the combined average of the original and revised models at the multiple group level.

Figure 5-4 - Multiple Group Shared Input and Combined Original and Revised Model VRS Averages



The above figure shows that the greatest difference lies between the average VRS of the shared input model and the average of the revised and original models for the Small Rural group of municipalities. For these council's, the shared input VRS average is 0.216 (21.6%) lower than the combined average of the original and revised Small Rural model averages. Although the largest difference between averages is 21.6%, we note the Small Rural municipalities had on average, comparatively lower efficiencies under the shared input model, as did all other groups except the Interface municipalities. The results at the multiple group level are summarised in the table below.

Table 5-2 - Shared Input DEA Multiple Group Results

Model	Mean Technical Efficiency		Standard Deviation of Technical Efficiency		On the frontier	
	CRS	VRS	CRS	VRS	CRS	VRS
Interface	0.86	0.93	0.13	0.09	2	4
Large Rural	0.87	0.90	0.13	0.12	4	9
Metropolitan	0.73	0.80	0.20	0.19	2	4
Regional Centre	0.83	0.89	0.18	0.13	2	5
Small Rural	0.69	0.77	0.20	0.21	2	5

5.2 LGPRF Shared Input DEA

A second shared input DEA model was developed using operating expenses as the input and the outputs listed below:

- **Planning Application Processing** – measured as the median number of days taken between receipt of a planning application and a decision on the application.
- **Library Loans** – measured as the number of library collection item loans per library collection item.
- **Animal Management Requests** – measured as the average number of days it has taken for council to action animal management requests.
- **Food Complaints –** measured as the average number of days it has taken for council to action food complaints received from members of the public about the safety or handling of food.

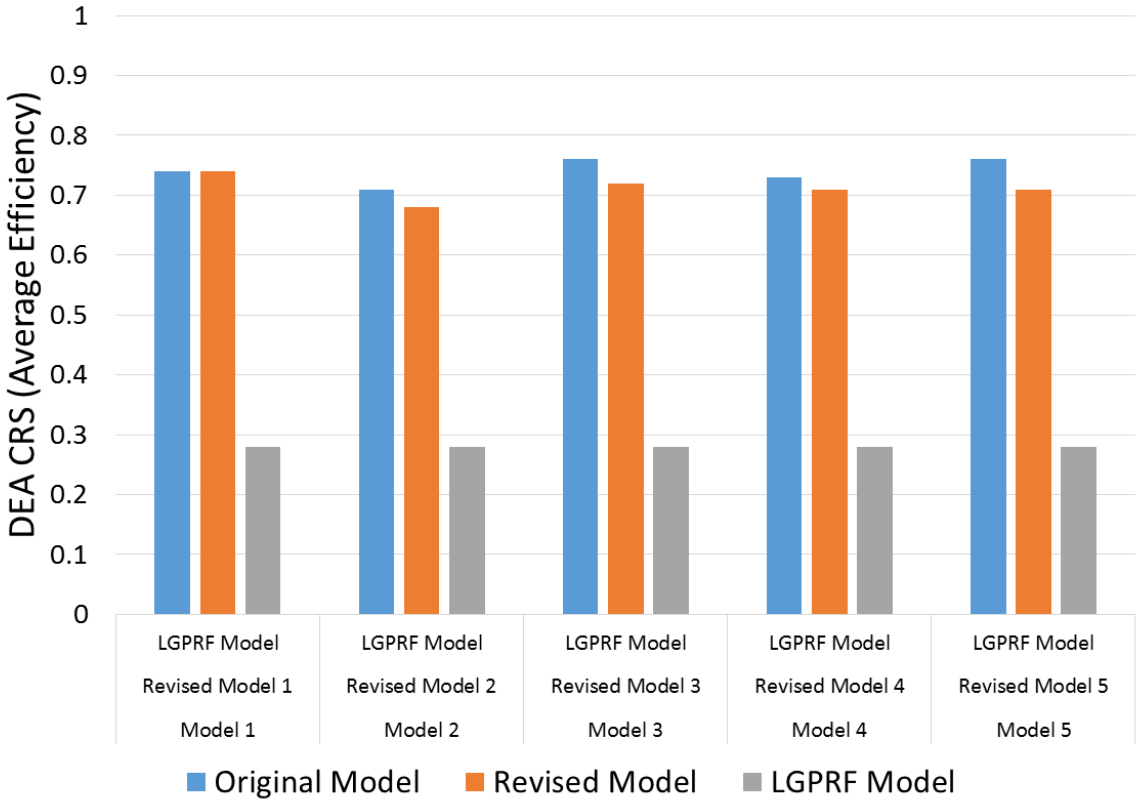
All outputs for this model were taken from the LGPRF dataset provided by the Commission. These outputs were chosen as they measure the output of the municipality at the service level and are common services provided by all municipalities. For certain outputs, three municipalities did not report outcomes. In these cases, the missing observations were dealt with by attributing the average value of the relevant groups i.e. Interface, Large Rural etc., in which the municipalities belong.

The LGPRF shared input model specification is defined as follows:

LGPRF Shared Input Model:	*Operating Expenses (excluding Depreciation) ($) = Planning Application Processing + Library Loans + Animal Management Requests + Food Complaints*

The chart below shows a comparison between the CRS averages of the LGPRF DEA and the original and revised models at the single group level.

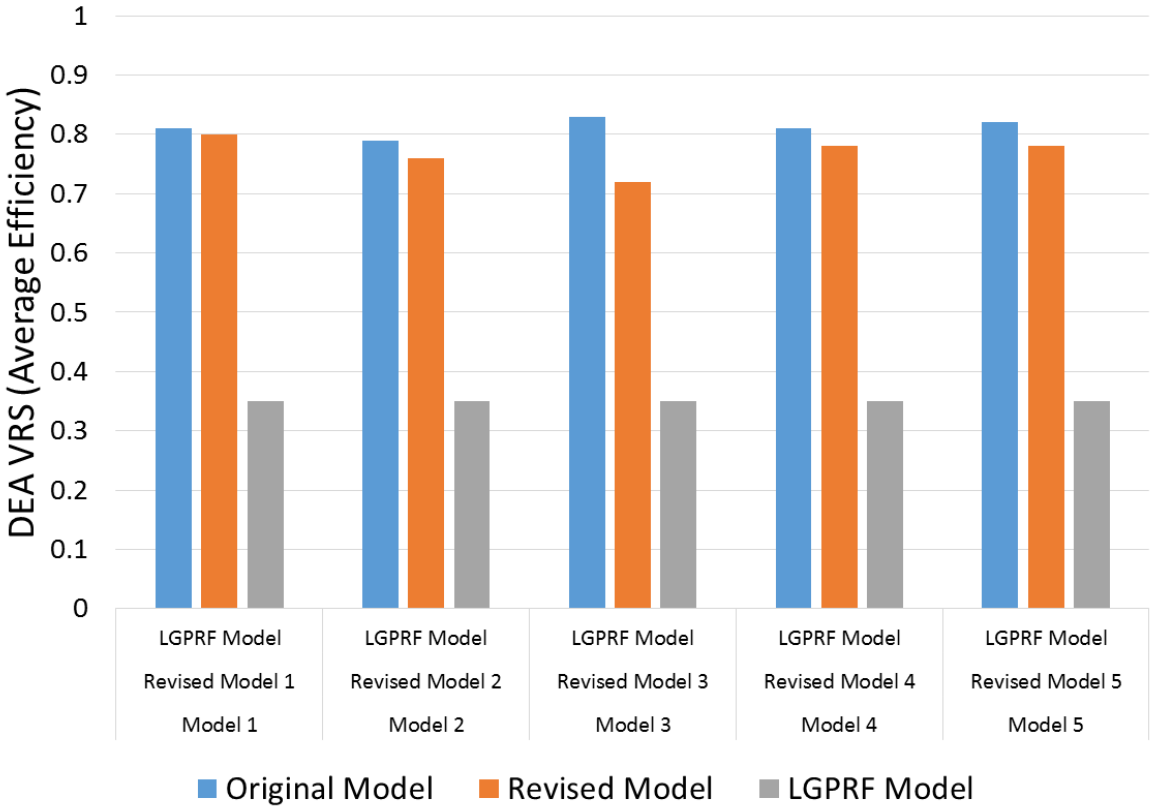
Figure 5-5 - Single Group CRS Averages of the Original, Revised and LGPRF DEA Models



The greatest difference with the original models exists between the LGPRF model and models 3 and 5 where the average CRS is 0.48 (48%) greater than the LGPRF model.

Across the revised models the largest difference is between Model 1 and the LGPRF model, where the Model 1 average CRS is 0.46 (46%) higher than that of the LGPRF model. Although the greatest difference between the LGPRF and the original and revised models is 48%, we note that on average the municipalities had lower efficiency values under the LGPRF model. The chart below shows a comparison between the VRS averages of the LGPRF DEA and the original and revised models at the single group level.

Figure 5-6 - Single Group VRS Average for Original, Revised and LGPRF DEA Models



The figure above indicates that when analysed as a single group, the average VRS of all municipalities is significantly lower under the LGPRF model. The largest difference with the original models exists between the LGPRF model and the original Model 3, where the average VRS is 0.48 (48%) larger than that of that of the LGPRF model.

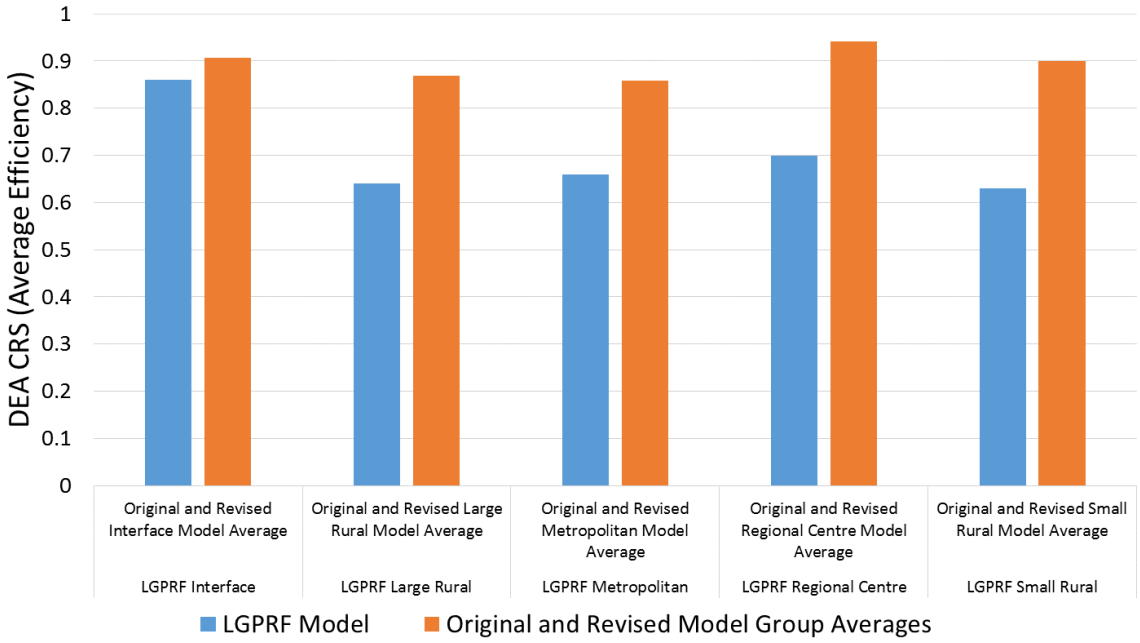
When comparing the revised models, Model 1 has the largest difference with an average CRS value 0.45 (45%) greater than that of the LGPRF model. Although the greatest difference between the LGPRF and the original and revised models is 48%, we note that on average, the municipalities had lower efficiency values under the LGPRF model. The results at the single group level have been summarised in the table below.

Table 5-3 – LGPRF Shared Input DEA Single Group Analysis Results

Model	Local Government Group	Mean Technical Efficiency		Standard Deviation of Technical Efficiency		On the frontier	
		CRS	VRS	CRS	VRS	CRS	VRS
LGPRF Shared Input	Single Group	0.28	0.35	0.25	0.31	3	8

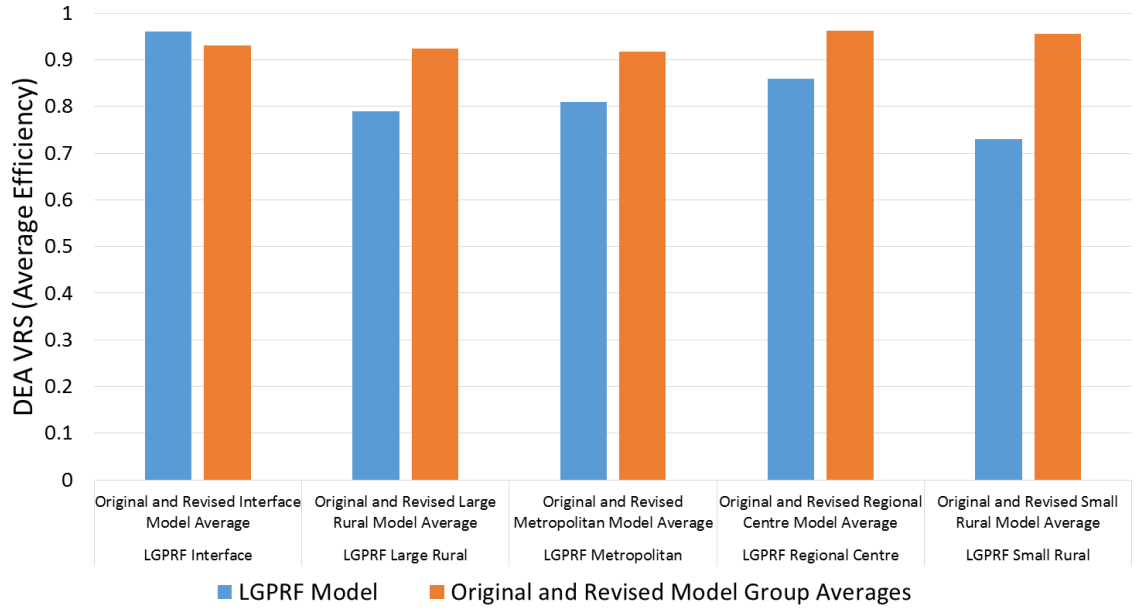
Figure 5-7 depicts the CRS averages of the LGPRF model and the combined averages of the original and revised model at the multiple group level.

Figure 5-7 - Multiple Group LGPRF and Combined Original and Revised Model CRS Averages



The chart demonstrates that under LGPRF model, each council had a lower average CRS compared to the combined average of the original and revised models. The largest difference was between the Regional Centre models where the LGPRF CRS average was 0.24 (24%) lower than the combined original and revised model average. We note that although the largest difference between the average of the original and revised models and the LGPRF model is 24%, the municipalities had on average, lower efficiency values under the LGPRF model at the multiple group level. Figure 5-8 depicts the VRS averages of the LGPRF model and the combined averages of the original and revised model at the multiple group level.

Figure 5-8 - Multiple Group LGPRF and Combined Original and Revised Model VRS Averages



The above figure indicates that all groups except the Interface municipalities, have a lower VRS efficiency under the LGPRF model. The greatest difference was between the efficiencies of the Small Rural municipalities where the LGPRF model's average VRS was 0.226 (22.6%) lower than the combined average of the original and revised models. We note that although the largest difference between the average of the original and revised models and the LGPRF model is 22.6%, the Small Rural municipalities had on average, comparatively lower efficiencies under the LGPRF model, as did all other municipalities except the Interface group. The full results at the multiple group level have been detailed in the table below.

Table 5-4 - LGPRF DEA Results at the Multiple Group Level

Local Government Group	Mean Technical Efficiency		Standard Deviation of Technical Efficiency		On the frontier	
	CRS	VRS	CRS	VRS	CRS	VRS
Interface	0.86	0.96	0.17	0.12	4	8
Large Rural	0.64	0.79	0.23	0.21	3	6
Metropolitan	0.66	0.81	0.24	0.18	6	9
Regional Centre	0.70	0.86	0.26	0.21	1	5
Small Rural	0.63	0.73	0.25	0.23	3	6

We note that the large difference in the results at the single group and multiple group level is due the fact that DEA is a relative measure, meaning that municipalities tend to perform better when compared to other they are similar to them.

5.3 Waste Management DEA

A DEA model measuring the efficiency of waste management services was developed. The inputs of the waste management DEA were:

- **Waste Collection Expenditure (excluding Depreciation) ($)** – total council expenditure on waste collection services.
- **Population Density –** the number of people per squared kilometer of the LGA.
- **Waste Cost Disposal Index (WCDI) –** indexed cost of council waste collection expenditure over time.

The outputs of the waste management DEA are:

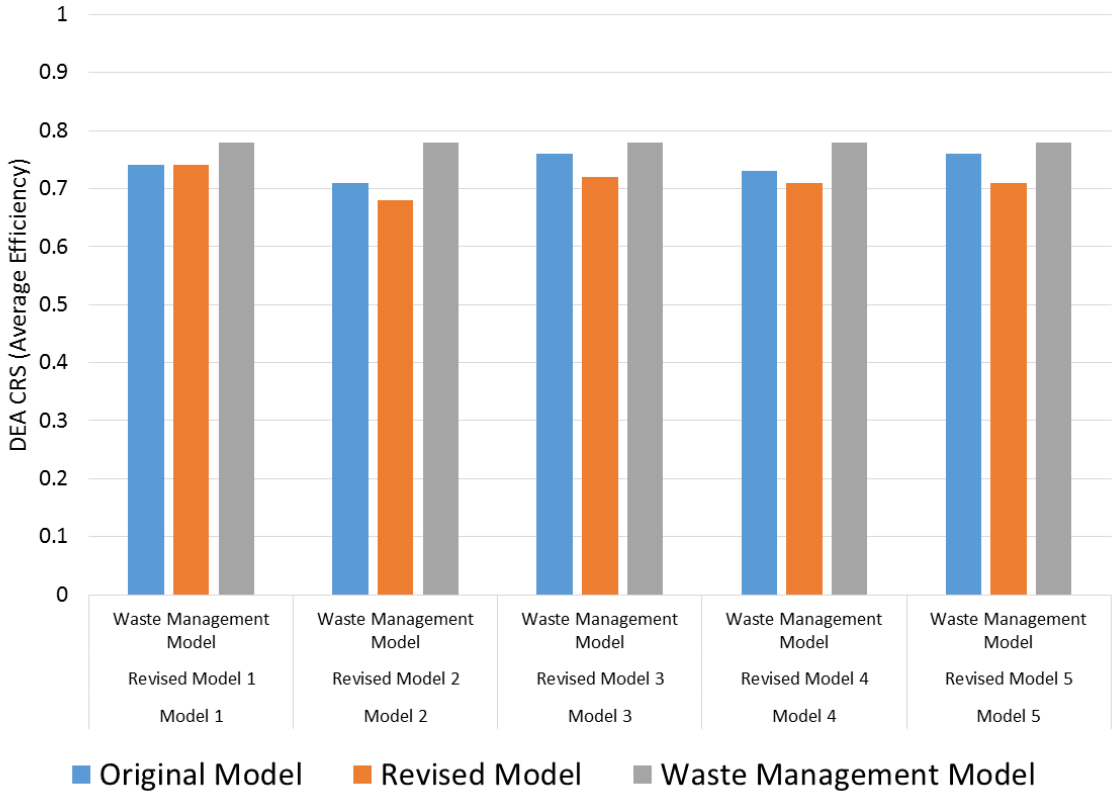
- **Total Garbage and Recyclables Collected** – total garbage and recyclables collected in tonnes.
- **Implied Recycling Rate –** recyclable waste as a proportion of total waste collected.

From these inputs and outputs, the waste management DEA is defined as follows:

Waste Management Model:	*Waste Collection Expenditure (excluding Depreciation) ($) + Population Density + WCDI = Total Garbage and Recyclables Collected + Implied Recycling Rate*

The chart below depicts the difference between the average CRS for the original and revised models and the waste management model at the single group level.

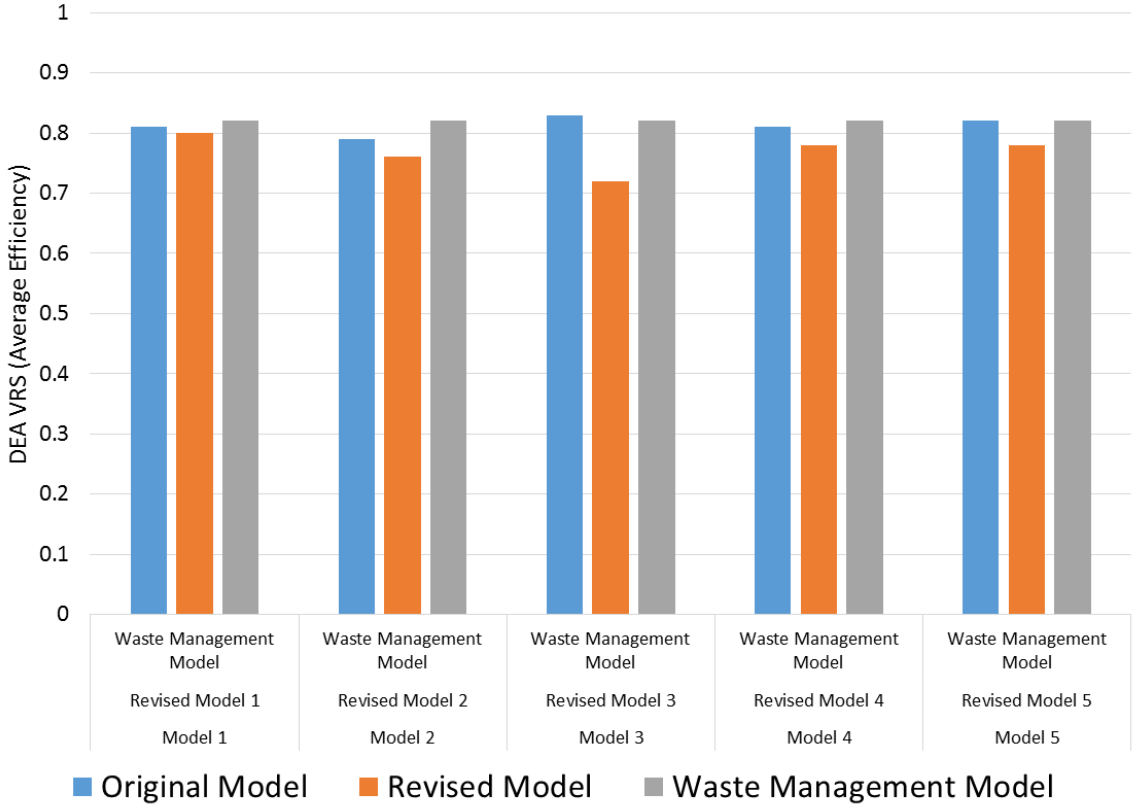
Figure 5-9 - Single Group CRS Averages of the Original, Revised and Waste Management DEA Models



The largest difference between the waste management and original models is between the original Model 2 and the waste management model. The average CRS of the waste management model is 0.07 (7%) greater than that of the original model 2.

The greatest difference between the waste management and revised models is between the revised Model 2 and the waste management model. The average CRS of the waste management model is 0.1 (10%) greater than that of the revised Model 2. As the largest difference between the original and revised models and the waste management model is 10%, the differences should not be regarded as statistically significant. The figure below shows the difference between the average VRS values of the original, revised and waste management models at the single group level.

Figure 5-10 - Single Group VRS Averages of the Original, Revised and Waste Management DEA Models



The largest difference between the waste management and original models is between the original Model 2 and the waste management model. The average VRS of the waste management model is 0.03 (3%) greater than that of the original Model 2.

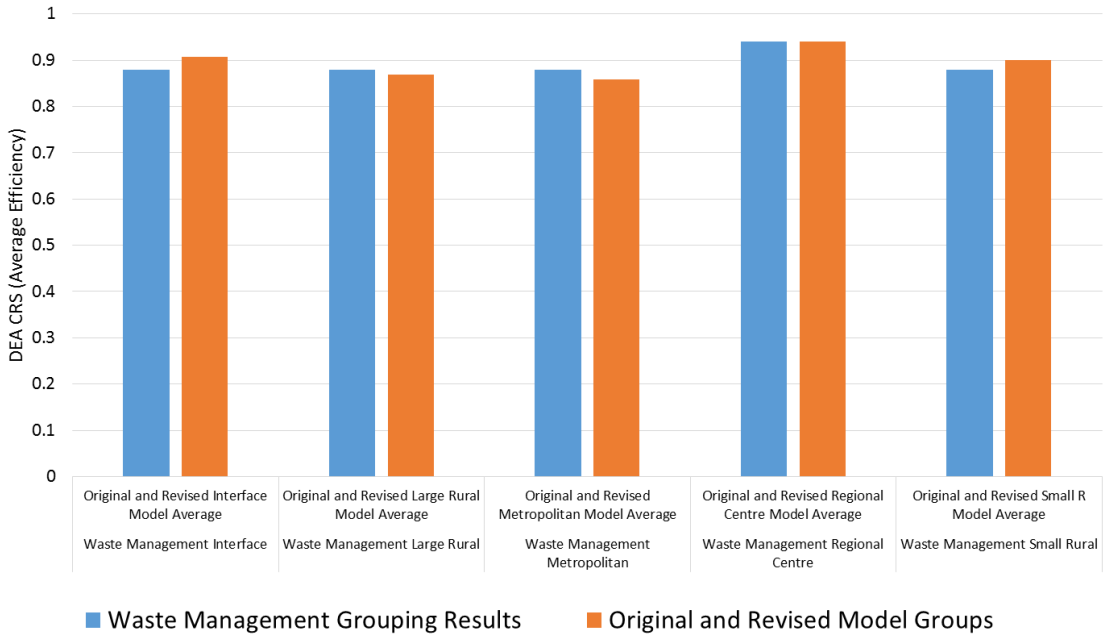
The greatest difference between the waste management and revised models is between the revised Model 3 and the waste management model. The average VRS of the waste management model is 0.1 (10%) greater than that of the revised Model 3. As the largest difference between the original and revised models and the waste management model is 10%, the difference should not be regarded as statistically significant. The full results at the single group level have been detailed in the table below.

Table 5-5 – Waste Management DEA Single Group Analysis Results

Model	Local Government Group	Mean Technical Efficiency		Standard Deviation of Technical Efficiency		On the frontier	
		CRS	VRS	CRS	VRS	CRS	VRS
Waste Management	Single Group	0.78	0.82	0.17	0.16	20	23

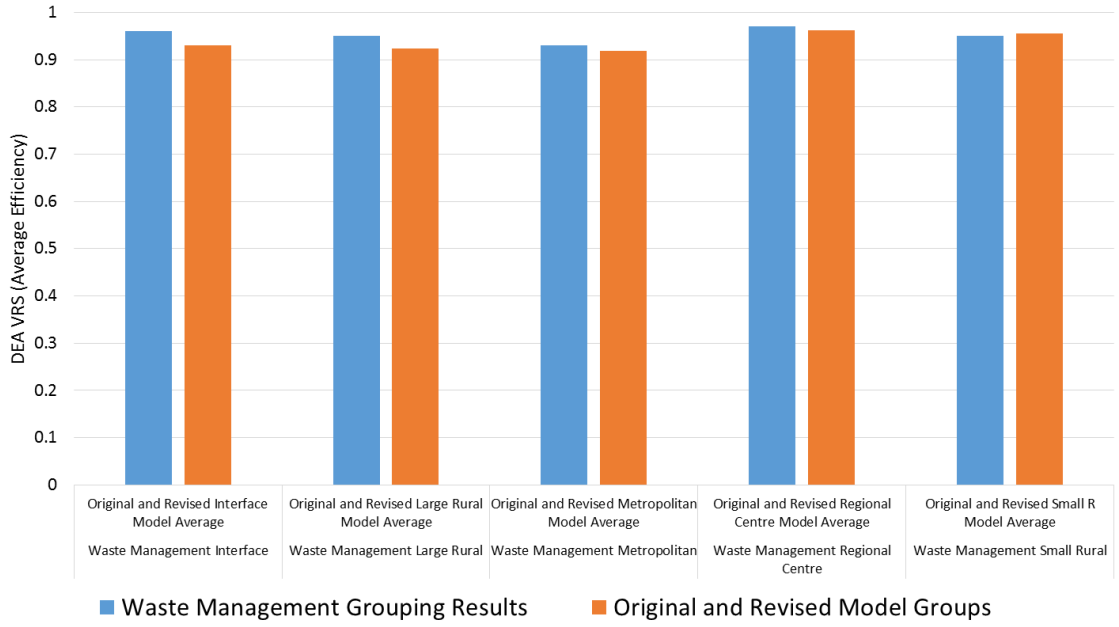
The chart below compares the CRS averages across the combined original and revised models to that of the of the waste management model at the multiple group level.

Figure 5-11 - Multiple Group Waste Management and Original and Revised Model CRS Averages



The chart above indicates the largest difference exits between the results for the Interface group of municipalities. The average CRS value of the combined original and revised models is approximately 0.027 (2.7%) greater than that of the waste management model. As the largest difference between the waste management model and the average of the original and revised models is 2.7%, the differences should not be considered statistically significant. The figure below compares the VRS averages of the original and revised models to the VRS average of the waste management model at the multiple group level.

Figure 5-12 - Multiple Group Waste Management and Original and Revised Model VRS Averages



The above figure indicates that the largest difference is between the Interface group of municipalities, where the waste management VRS average is approximately 0.03 (3%) greater than the combined average VRS of the original and revised models. As the largest difference between the waste management model and the average of the original and revised models is 3%, the differences should not be considered statistically significant. The full waste management model results at the group level have been summarised in the table below.

Table 5-6 – Multiple Group Waste Management DEA Results

Local Government Group	Mean Technical Efficiency		Standard Deviation of Technical Efficiency		On the frontier	
	CRS	VRS	CRS	VRS	CRS	VRS
Interface	0.88	0.96	0.19	0.07	5	7
Large Rural	0.88	0.95	0.15	0.10	9	12
Metropolitan	0.88	0.93	0.11	0.11	6	13
Regional Centre	0.94	0.97	0.11	0.11	7	9
Small Rural	0.88	0.95	0.17	0.10	7	13

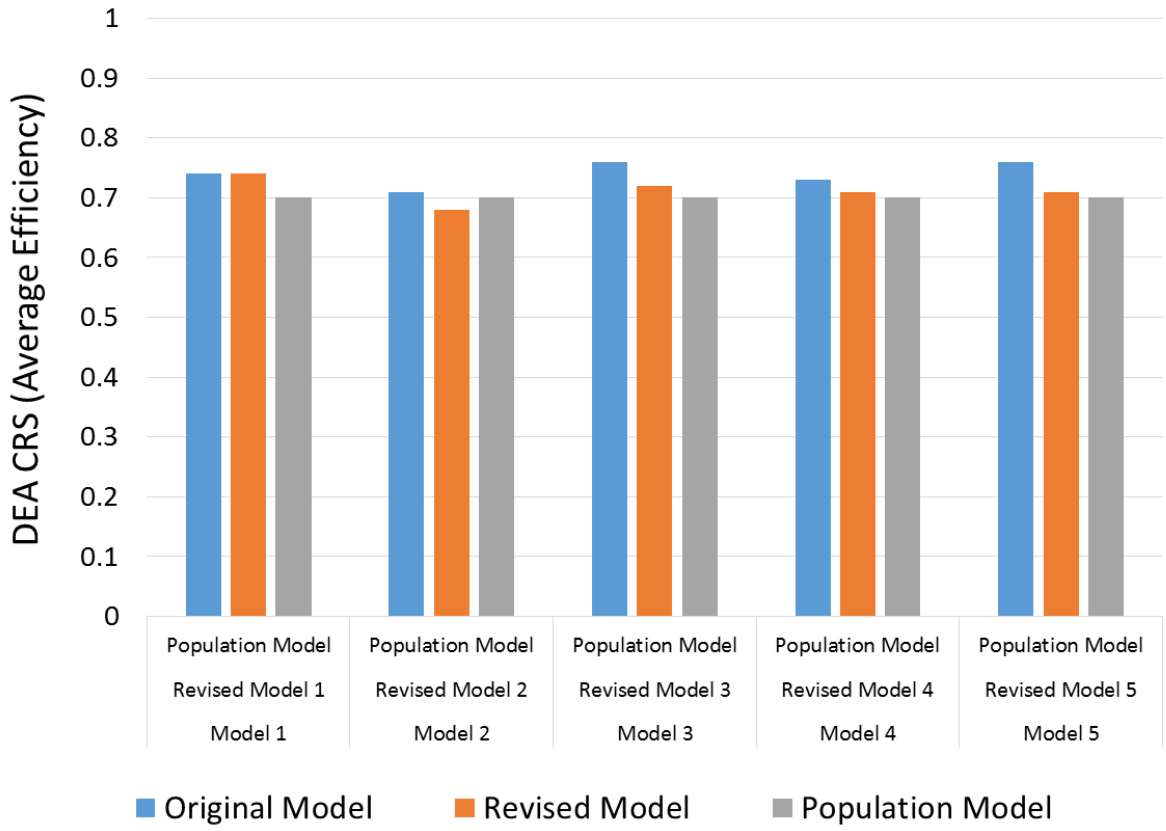
6 Population as an Output

To create a population DEA model, the revised Model 1 specification has had population included as a model output. Figure 6-1 below depicts the CRS averages of the population, original and revised models at the single group level. The specification of the population model is represented by the following equation:

Population Model:	*Staff ($) + Operating Expenses (excluding Depreciation and Staff) ($) = Businesses + Roads + Population*

The chart below depicts the difference between the average CRS of the original, revised and population model at the single group level.

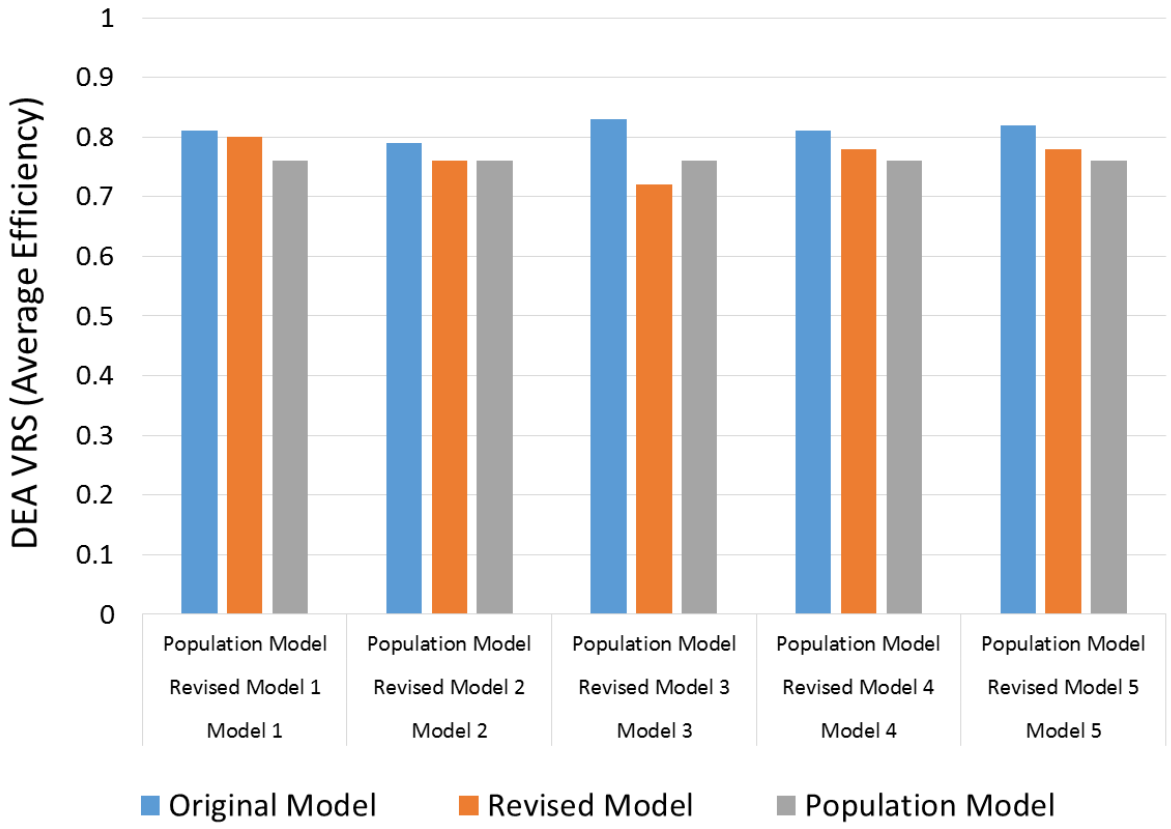
Figure 6-1 - Single Group CRS Averages of the Original, Revised and Population DEA Models



The figure above suggests that the greatest difference lies between the population model and the original models 3 and 5. The average CRS of the population model is 0.06 (6%) lower than that of the original models 3 and 5.

The greatest difference between the population and the revised models is between the population model and the revised Model 1, where the population CRS average is 0.04 (4%) lower than that of the revised Model 1. As the largest difference between the population and the original and revised models is 6%, the differences between the models should not be considered statistically significant. The figure below depicts the differences between the average VRS of the original, revised and population models.

Figure 6-2 - Single Group VRS Averages of the Original, Revised and Population DEA Models



The figure above indicates that the greatest difference across the original models is between the population model and the original Model 3. The average VRS of the population model is 0.07 (7%) lower than that of the original Model 3.

The greatest difference between the population and the revised models is between the population and revised models 1 and 3, where the average population model VRS differs by 0.04 (4%) from revised models 1 and 3. As the largest difference between the population and the original and revised model is 7%, the differences between the models should not be considered statistically significant. The single group results of the population DEA have been summarised in the table below.

Table 6-1 – Population DEA Single Group Analysis Results

Model	Local Government Group	Mean Technical Efficiency		Standard Deviation of Technical Efficiency		On the frontier	
		CRS	VRS	CRS	VRS	CRS	VRS
Population Model	Single Group	0.70	0.76	0.16	0.15	8	13

Figure 6-3 compares the CRS combined average of the original and revised models to those of the population model at the multiple group level.

Figure 6-3 - Multiple Group Population and Combined Original and Revised Model CRS Averages

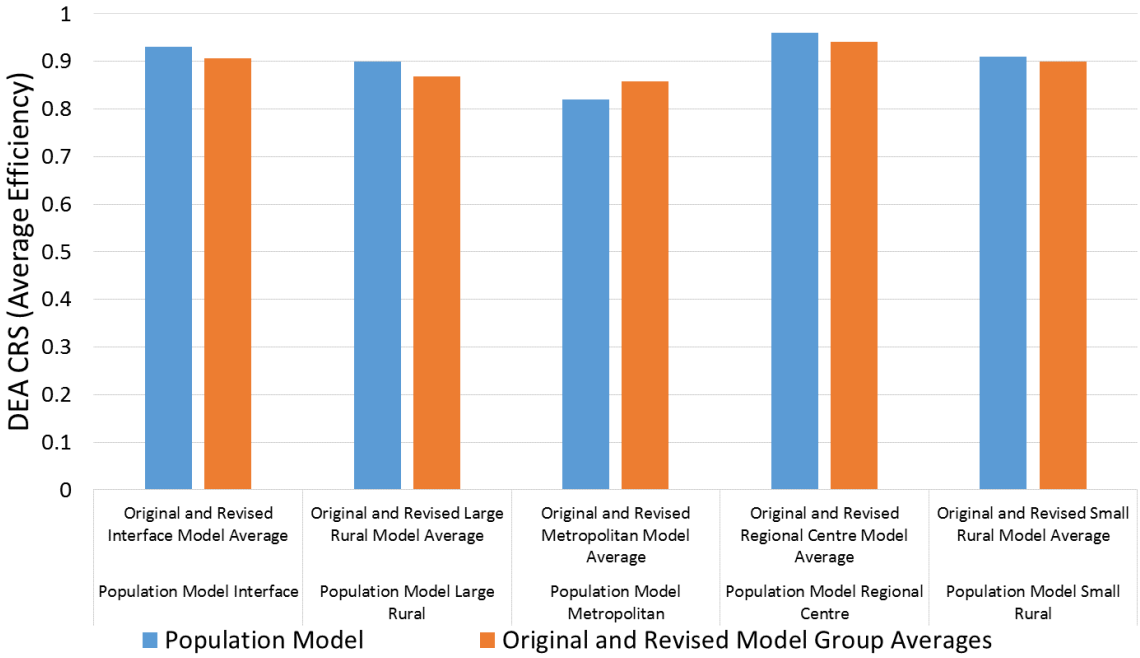


Figure 6-3 indicates that the greatest difference between the CRS averages lies between the models of the Metropolitan group of municipalities where the population model is 0.04 (4%) lower than the combined average. As the largest difference between the population model and the average of the original and revised models is 4%, the differences between the models should not be considered statistically significant. The figure below compares the VRS averages of the combined original and revised models to that of the population model at the multiple group level.

Figure 6-4 - Multiple Group Population and Combined Original and Revised Model VRS Averages

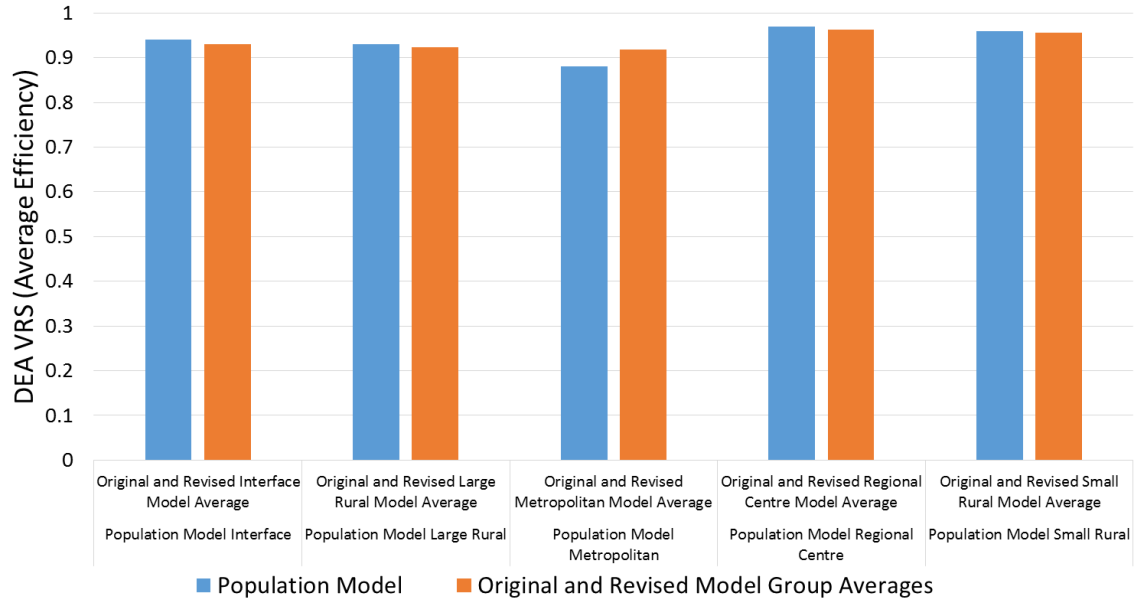


Figure 6-4 shows the greatest difference at the multiple group level is between the Metropolitan models. The average VRS of the population model differs by approximately 0.04 (4%) compared to the combined averages of the original and

revised models. As the largest difference between the waste management model and the average of the original and revised models is 4%, the differences between the models should not be considered statistically significant. The population model results at the multiple group level have been summarised in the table below.

Table 6-2 - Multiple Group Population DEA Results

Local Government Group	Mean Technical Efficiency		Standard Deviation of Technical Efficiency		On the frontier	
	CRS	VRS	CRS	VRS	CRS	VRS
Interface	0.93	0.94	0.11	0.11	5	6
Large Rural	0.90	0.93	0.13	0.11	5	11
Metropolitan	0.82	0.88	0.15	0.11	5	7
Regional Centre	0.96	0.97	0.09	0.07	7	8
Small Rural	0.91	0.96	0.10	0.05	5	9