Australian Bureau of Statistics

CAPACITY TO CONTRIBUTE: ALTERNATIVE STATISTICAL MEASURES FOR USE IN THE DMI METHODOLOGY – PRELIMINARY RESULTS

Direct Measure of Income Refinement Working Group Paper

February 2021

CAPACITY TO CONTRIBUTE: ALTERNATIVE STATISTICAL MEASURES FOR USE IN THE DMI METHODOLOGY – PRELIMINARY RESULTS

Executive Summary

The Australian Bureau of Statistics (ABS) is evaluating the fitness-for-purpose of six alternative statistical summary measures that could be used in the Direct Measure of Income (DMI) methodology for calculating Capacity to Contribute (CTC). These summary measures are:

- the first quartile;
- the mid-hinge;
- the tri-mean;
- the mean;
- the trimmed mean; and
- the winsorised mean.

Definitions of these measures, as well as the median, are provided in Appendix 1. A detailed introduction to these measures was provided in the January 2021 DMI Refinement Working Group paper, Capacity to Contribute: Introduction to alternative statistical measures for use in the DMI methodology, and is available at the DESE website.

A key issue raised by stakeholders at the January DMI Refinement Working Group meeting concerned the principles which could be used to assess the alternative statistical summary measures. In this paper, the ABS proposes and seeks feedback from the working group on a framework consisting of six principles, as shown in Table 1, below.

Table 1: Proposed conceptual framework for assessing alternative statistical summary measures for the DMI.

Principle	Definition	Key assessment criteria
1. Relative orientation to the DMI score	The extent to which scores based on alternative measures are the same as, higher than, or lower than the DMI score.	Difference between score based on alternative measure and the DMI score based on the median.
2. Volatility	A measure of the change in a data item over time.	The annual change in score, from 2018-2020.
3. Confidentiality	The requirement to protect the secrecy and privacy of information collected from individuals.	The impact of mitigating confidentiality risks on the availability, accuracy, complexity and interpretability of scores and supplementary data.
4. Accuracy	The degree to which data correctly describes the "real world" object or event.	The impact of technical decisions, such as the trimming parameter and winsorisation threshold. The sensitivity of scores to missingness and refinements to the CTC income imputation strategy.

Principle	Definition	Key assessment criteria
5. Robustness to extreme income values	The extent to which the measure is stable in the presence of extreme income values.	The extent to which scores change when outliers are introduced. Differences between scores based on alternative measures and the DMI score based on the median, for schools with a large proportion of outliers.
6. Sensitivity to distributional differences	The degree to which a statistical measure changes value in response to distributional changes.	How scores based on the alternative measures reflect differences in school income distributions.

The ABS notes that other principles may be important to stakeholders. Furthermore, the six principles may not necessarily be equally weighted, and the importance of each principle may vary.

This paper also presents preliminary analyses of the first three principles: (1) relative orientation to the DMI score, (2) volatility and (3) confidentiality. The findings of the analyses are summarised in Table 2 below. The ABS will present analyses of the remaining three principles – (4) accuracy, (5) robustness to extreme values, and (6) sensitivity to distributional differences – in March 2021 (subject to feedback from the DMI Refinement Working Group on the proposed framework).

Summary of preliminary assessment

Table 2: Summary of preliminary assessment against the principles of relative orientation to the DMI score, volatility and confidentiality.

Summary measure	Relative orientation to the DMI score	Volatility	Confidentiality
First quartile	Scores tend to increase, with some increasing by a relatively large amount. Scores increase for the majority of schools in the 96 to 114 DMI score range.	Slightly less stable than the DMI score. Slightly more schools have some annual change in score. Average score changes are slightly larger in magnitude than those of DMI score.	Similar risk level and treatments to the DMI score. Slightly lower availability, due to the larger minimum number of contributing family incomes (20 compared with 10 for the DMI).
Mid-hinge	Similar to the mean, but differences are smaller in magnitude.	Slightly more stable than the DMI score.	Same as first quartile.
Tri-mean	Scores are similar to DMI scores. A large proportion of schools have no score difference across the DMI score ranges. Scores decrease for a majority of schools in the 105 to 114 DMI score range.	Slightly more stable than the DMI score.	Same as first quartile.
Mean	Scores tend to decrease, with some decreasing by a relatively large amount. Scores decrease for a large majority of schools in the 96 to 119 DMI score range.	Slightly more stable than, or similar to, the DMI score.	Availability is similar to median. Higher risk level than DMI score based on median. More complex treatment required to ensure safe data release. Further work required to determine safe release strategy for measure and supporting information. Potential impact on existing privacy framework.
Trimmed mean	Similar to the mean, but differences are smaller in magnitude.	Slightly more stable than the DMI score.	Similar to mean.
Winsorised mean	Similar to the mean, but differences are smaller in magnitude.	Slightly more stable than the DMI score.	Similar to mean.

1. Introduction

In 2020-21, the Australian Bureau of Statistics (ABS) was engaged by the Department of Education, Skills and Employment (DESE), to evaluate the fitness-for-purpose of alternative statistical summary measures that could be used in the Direct Measure of Income (DMI) methodology for calculating Capacity to Contribute (CTC). As part of this engagement, the ABS is evaluating the following six alternative statistical summary measures:

- the first quartile;
- the mid-hinge;
- the tri-mean;
- the mean;
- the trimmed mean; and
- the winsorised mean.

Definitions of these measures, as well as the median, are provided in Appendix 1. A detailed description of these measures was provided in the January 2021 DMI Refinement Working Group paper, 'Capacity to Contribute: Introduction to alternative statistical measures for use in the DMI methodology', and is available at the DESE website.

Background

CTC is a measure of the anticipated capacity of a non-government school community to financially contribute to the operating cost of schooling. Under the Australian Education Act 2013 (Cth), the national school funding model uses CTC, as one of several factors, to inform the level of recurrent Australian Government funding for most non-government schools' operations[1]. This constitutes one component of Australian Government funding for non-government schools.

The DMI methodology has been used in the CTC assessment since 2020. It represents a change from the previous approach, which was based on the characteristics of the areas in which school students lived[2]. Under this methodology, a DMI score is calculated for each non-government school based on the median income of parents and guardians of the students attending the school[3]. Due to data availability, in 2020 the CTC score was the average of each school's DMI scores for the two most recent years and from 2021 onwards, it will be the average of each school's DMI scores for the three most recent years.

[1] Some non-government schools, such as special schools, special assistance schools, sole provider schools, and majority Aboriginal and Torres Strait Islander schools, are subject to alternative funding arrangements. Also, the CTC assessment does not apply to some students, such as overseas and distance education students. These schools and students are excluded from the ABS' analysis of alternative statistical measures.
For further information about Australian Government funding of schools, see: https://www.dese.gov.au/quality-schools-package/quality-schools-fact-sheets.

[2] Further information about the change to the DMI methodology is available on DESE's website, at the link above.

[3] For further information, see the fact sheet 'What is the methodology for the Direct Measure of Income (DMI)?', available at the DESE website.

Overview

This paper proposes a principles-based framework to support the assessment of alternative statistical summary measures for potential use in CTC (see Section 2). The conceptual framework consists of six principles, namely:

1. Relative orientation to the DMI score;
2. Volatility;
3. Confidentiality;
4. Accuracy;
5. Robustness to extreme income values (outliers); and
6. Sensitivity to distributional differences.

This paper also presents preliminary analyses of the first three principles: (1) relative orientation to the DMI score (see Section 3), (2) volatility (see Section 4) and (3) confidentiality (see Section 5).

The ABS will present analyses of the remaining three principles – (4) accuracy, (5) robustness to extreme values, and (6) sensitivity to distributional differences – in March 2021 (subject to feedback from the DMI Refinement Working Group on the proposed assessment framework).

Methodology

For the DMI score (based on the median) and each alternative statistical summary measure, school scores were calculated by:

i. taking the summary measure of the school's family income distribution;
ii. standardising the summary measure to obtain a score;
iii. rounding the score to the nearest integer; and
iv. bottom and top coding to 93 and 125, respectively.

In using this approach to create scores based on alternative measures, all other aspects of the DMI methodology, such as the income imputation strategy and standardisation process used to convert summary income values into scores, were held constant.[4] This approach ensured that the differences in school scores described in this paper result solely from the use of the alternative summary measures.

Analysis of the potential impact of using alternative statistical summary measures on school funding is out-of-scope of the ABS' engagement. However, to support the analysis of score changes which have an impact on funding, schools with scores below 93 were assigned a score of 93, and schools with scores above 125 were assigned a score of 125 in this analysis.

[4] Standardisation is a common statistical process which converts a set of numbers, which may have any average and spread, into a pre-determined average and spread. It does not change the order of school communities in the distribution. For CTC, income imputation refers to the methods used to determine a value of Adjusted Taxable Income (ATI) for those parents whose ATI is missing in the linked administrative data available via the Multi-Agency Data Integration Project (MADIP).

To be included in the comparison of DMI scores with scores based on an alternative measure, schools must meet the confidentiality requirements of both the median and the alternative measure. Confidentiality requirements are described in more detail in Section 5.

2. Principles-based framework for assessing alternative summary measures

In this section, the ABS proposes a conceptual framework consisting of six principles with which to assess the fitness-for-purpose of the alternative statistical summary measures for use in the DMI methodology. Feedback from the DMI Refinement Working Group is welcomed as the ABS notes that the six proposed principles may not necessarily be equally weighted in terms of importance and that there may be other principles of importance to stakeholders that are not captured in the proposed assessment framework presented below.

Proposed principles

The six proposed principles are outlined below, including a definition, rationale and key assessment criteria.

Principle 1 - Relative orientation to the DMI score

Definition:
The extent to which scores based on alternative summary measures are the same as, higher than or lower than the DMI score based on the median.

Rationale:
This principle enables stakeholders to understand the impact an alternative summary measure would have on school scores compared to using the median, as it has a direct impact on the funding schools receive. This principle should be assessed in conjunction with Principles 5 and 6 in particular, as these principles are concerned with assessing the behaviour of the alternative summary measures with respect to characteristics of school community income distributions.

Key assessment criteria:

- Differences between scores based on the alternative summary measures and the DMI score based on the median.
- Distribution of differences between scores based on the alternative summary measures and the DMI score based on the median, for selected sub-categories of schools.

Principle 2 - Volatility

Definition:
A measure of the change in a data item over time.

Rationale:
From year to year, the income distribution of a school will change, as the population of the school community changes. It is reasonable to expect that this change will not typically be large. Ideally, the statistical measure on which a school's score is based will change in response to the change in the school community population from year to year and result in a stable DMI score.

From a practical perspective, it is preferable that there is a level of stability in the funding schools receive from year to year. To an extent, the stability of the CTC score is supported by the use of the rolling average of the most recent three DMI scores for CTC funding purposes.

Key assessment criteria:

- Proportion of schools whose scores based on the alternative summary measures increase, decrease or do not change annually, compared to the corresponding changes in DMI scores based on the median, for 2018-2020.
- Magnitude of the increase and decrease in scores based on the alternative summary measures, compared to that of the DMI scores based on the median, for 2018-2020.

Principle 3 - Confidentiality

Definition:
The requirement to protect the secrecy and privacy of information collected about individuals.

Rationale:
Protecting the privacy and confidentiality of individuals who make up the CTC population is a paramount consideration in the design and implementation of the DMI methodology. The alternative summary measures pose varying levels of disclosure risk compared to the median and the treatments necessary for mitigating these varying disclosure risk levels will have differing implications for the availability, accuracy, complexity and interpretability of scores for schools and supplementary data.

Key assessment criteria:

- The impact of mitigating disclosure risks on the availability, accuracy, complexity and interpretability of scores and supplementary data.

Principle 4 - Accuracy

Definition:
The degree to which data or a statistical measure correctly describes the “real world” object or event they were intended to measure.

Rationale:
Accuracy is an important component of quality as it relates to how well the summary measure reflects the ‘true’ income distribution of a school. Sensitivity to missing income values and imputation strategies, as well as the intrinsic statistical properties of the summary measure may all affect the level of accuracy of a statistical summary measure. This has clear implications for how useful and meaningful the measure is for its intended purpose.

In the DMI methodology, the statistical summary measure is required to be a single number that represents the anticipated CTC of the school community, relative to other schools. The median meets this requirement as it is a single number that is intended to measure the ‘central tendency’ of a distribution which allows schools to be ranked relative to each other’s ‘central’ position on an income number scale. All but the first quartile share these qualities with the median. The first

quartile also allows schools to be ranked relative to each other's position on a number scale, but it is conceptually different, in that it is a single number that is intended to measure the position of the first quarter of a distribution.

Key assessment criteria:

- Sensitivity of the alternative summary measures to missing incomes / income imputation, compared to the sensitivity of the median to missing incomes / income imputation.
- The impact of methodological decisions such as the trimming parameter and winsorisation threshold, on the ability of the alternative summary measures to summarise the school community's income distribution.

Principle 5 – Robustness to extreme income values

Definition:
The extent to which a statistic is stable in the presence of extreme values.

Rationale:
The summary measure used in the DMI methodology is required to summarise the school community income distribution. It is preferable that the summary measure is not heavily impacted by the presence of extreme family income values and represents the majority of family income values in the school community.

Key assessment criteria:

- A comparison of the extent to which scores based on the median and the alternative summary measures change when extreme outlier income values are introduced into school community income distributions.
- Differences between scores based on the alternative summary measures and the DMI score based on the median, for schools with varying proportions of extreme outlier income values.

Principle 6 – Sensitivity to distributional differences

Definition:
The degree to which a statistical measure changes value in response to distributional changes.

Rationale:
While robustness to outliers is an ideal quality for the summary measure used in the DMI methodology, responsiveness to distributional changes may also be an ideal quality. For example, if the incomes of a significant proportion of a school community changes (this may occur due to a new cohort of students joining a school in place of a graduating cohort of students), it should be reflected appropriately in the summary measure and resulting DMI score for that school.

Key assessment criteria:

- Differences between scores based on the alternative summary measures and the DMI score based on the median, for schools with different distributional characteristics (for example, a large proportion of families with low incomes).

3. Relative orientation to the DMI score

Difference between scores based on alternative measures and DMI score

The relative orientation of scores based on the alternative measures, to the DMI score, is indicated by the difference in scores. Differences were calculated by subtracting a school's DMI score from its score based on the alternative summary measure. Differences were calculated using the rounded and top and bottom coded scores. For example, a school with a score of 93 based on the first quartile and a DMI score of 94, would have a difference of -1. A negative difference, such as in this example, indicates the score based on the alternative measure is less than the DMI score. That is, it represents a decrease in score.

Summary

Table 3 summarises the key differences between the alternative measures, in terms of their relative orientation to the DMI score, in 2020.

Table 3: Summary of key differences between alternative measures, for relative orientation to the DMI score, 2020.

Alternative measure	Difference between scores based on alternative measure and DMI score	Distribution of differences, by DMI score range
First quartile	Scores tend to increase, with some increasing by a relatively large amount.	Scores increase for a majority of schools in the 96 to 114 DMI score range.
Mid-hinge	Similar to the mean, but differences are smaller in magnitude.	Scores decrease for a majority of schools in the 102 to 119 DMI score range.
Tri-mean	Scores are similar to DMI scores.	A large proportion of schools have no score difference across the DMI score ranges. Scores decrease for a majority of schools in the 105 to 114 DMI score range.
Mean	Scores tend to decrease, with some decreasing by a relatively large amount.	Scores decrease for a large majority of schools in the 96 to 119 DMI score range.
Trimmed mean	Similar to the mean, but differences are smaller in magnitude.	Similar to the mean.
Winsorised mean	Similar to the mean, but differences are smaller in magnitude.	Similar to the mean.

Detailed analysis

For each alternative measure, Table 4 summarises the proportion of schools which have an increase, no difference or decrease in the score based on the alternative measure, compared with the 2020 DMI score. For all measures, a large proportion of schools have no difference between the score based on the alternative measure and the DMI score. Scores based on the tri-mean are the most similar to DMI scores, with 64% of schools having no difference in score.

The first quartile is the only alternative measure for which more schools have an increase in score than a decrease, compared with the DMI score. The score based on the first quartile is higher than the DMI score for 43% of schools. The magnitude of differences for scores based on the first quartile is also relatively large. For a quarter of schools (25%), the score based on the first quartile is three or more points higher than the DMI score.

Scores based on the mean also show a relatively high number and magnitude of differences when compared with the DMI score. However, the score based on the mean is lower than the DMI score for 43% of schools. 18% of schools have a decrease in score of 3 or more points when the mean is used. Scores based on the trimmed mean and the winsorised mean show a similar pattern in terms of their difference from the DMI score, however, especially for the trimmed mean, the number and magnitude of differences is smaller.

Table 4: Summary of differences in score based on alternative measures compared with DMI score, 2020.

Alternative measure	Increase in score (%)	No difference (%)	Decrease in score (%)
First quartile	43%	38%	19%
Mid-hinge	16%	49%	35%
Tri-mean	10%	64%	26%
Mean	22%	35%	43%
Trimmed mean	16%	46%	38%
Winsorised mean	17%	42%	41%

Figures 1-6 show the distribution of the differences between scores based on each alternative measure and the DMI score, for 2020.

Figure 1: Distribution of differences between score based on first quartile and DMI score, 2020.

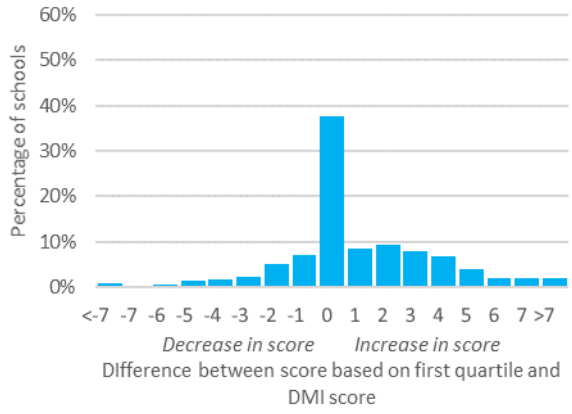


Figure 2: Distribution of differences between score based on the mid-hinge and the DMI score, 2020.

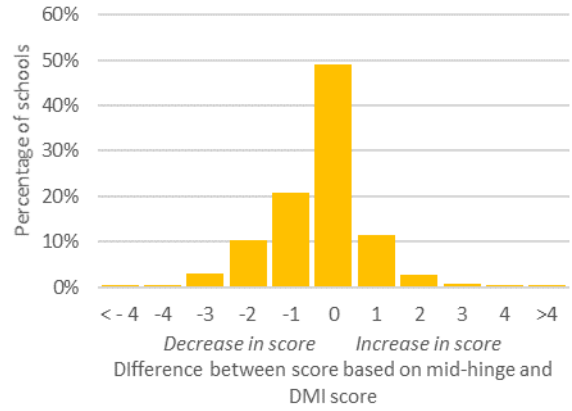


Figure 3: Distribution of differences between score based on tri-mean and DMI score, 2020.

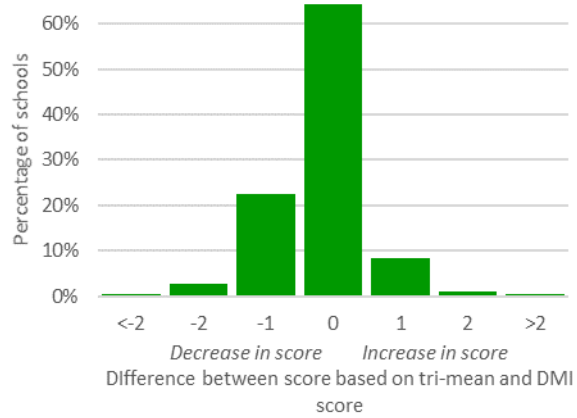


Figure 4: Distribution of differences between score based on mean and DMI score, 2020.

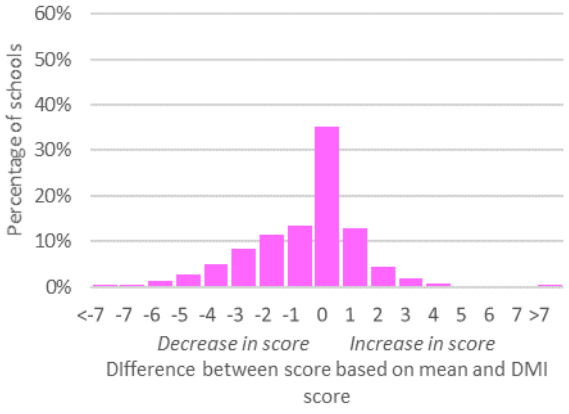


Figure 5: Distribution of differences between score based on trimmed mean and DMI score, 2020.

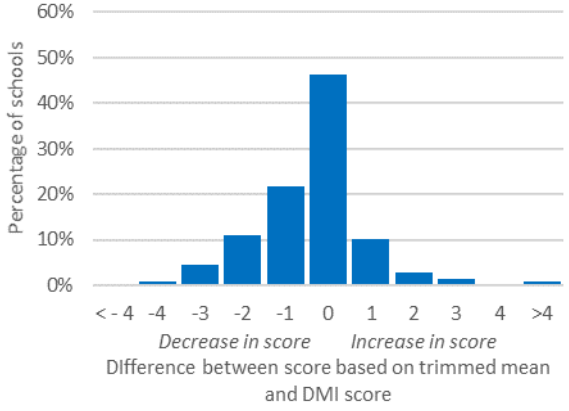
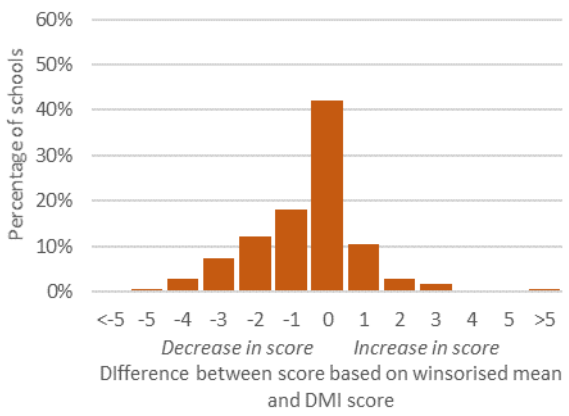


Figure 6: Distribution of differences between score based on winsorised mean and DMI score, 2020.



Differences in score, by 2020 DMI score

Analysis of the difference between scores based on the alternative measures and DMI scores, by 2020 DMI score category, is provided below.

The difference between scores based on the alternative measures and DMI scores varies by DMI score. However, this is due, in part, to the top and bottom coding of scores at 125 and 93 respectively. That is, a high proportion of schools with a 2020 DMI score of 93 or 125 have no change in score, while score changes are more prevalent among schools with DMI scores between 94 and 124. The magnitude and direction of score changes differs according to the statistical summary measure on which the scores are based.

For each alternative measure, Figures 7-18 below show both the counts and the proportion of schools with a given difference in score in each DMI score category.

First quartile

Figures 7 and 8 show the difference between scores based on the first quartile and DMI scores in 2020, by 2020 DMI score range. For a large proportion of schools with DMI scores of 93 to 95 (76%) and 120 to 125 (49%), the score based on the first quartile and DMI score are the same. As noted above, this is partly due to the top and bottom coding of scores below 93 and above 125.

For schools with DMI scores between 96 and 119, the score based on the first quartile is higher than the DMI score for the majority of schools. Using the first quartile resulted in an increase in score for almost three-quarters (72%) of schools in the 102 to 104 DMI score range, 78% of schools in the 105 to 108 DMI score range, and 76% of schools in the 109 to 114 DMI score range.

Figure 7: Distribution of differences between score based on the first quartile and DMI score, 2020, number of schools by DMI score range.

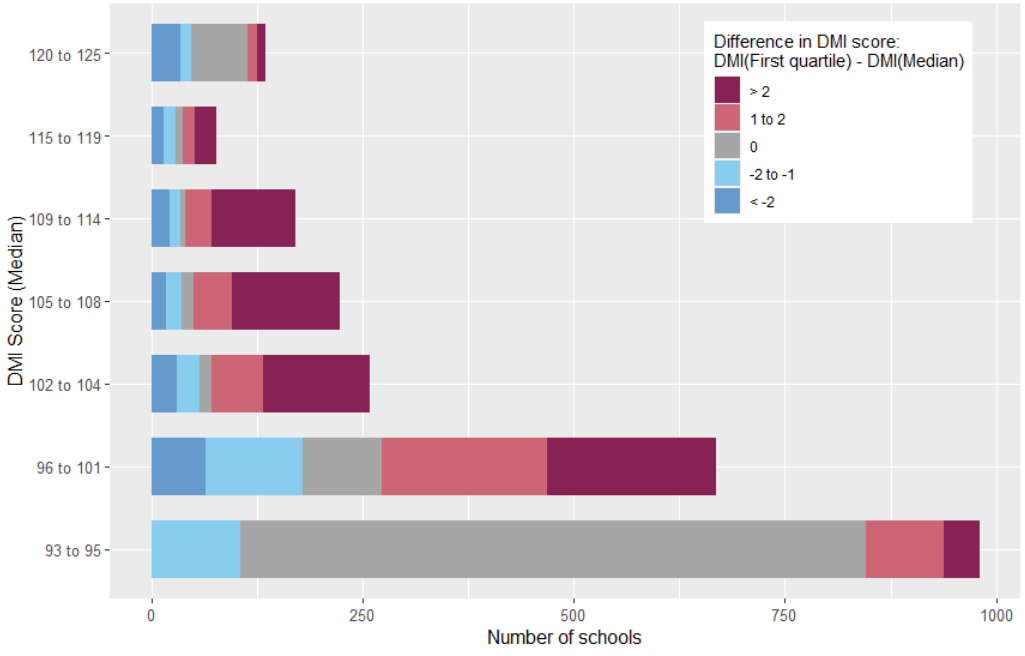
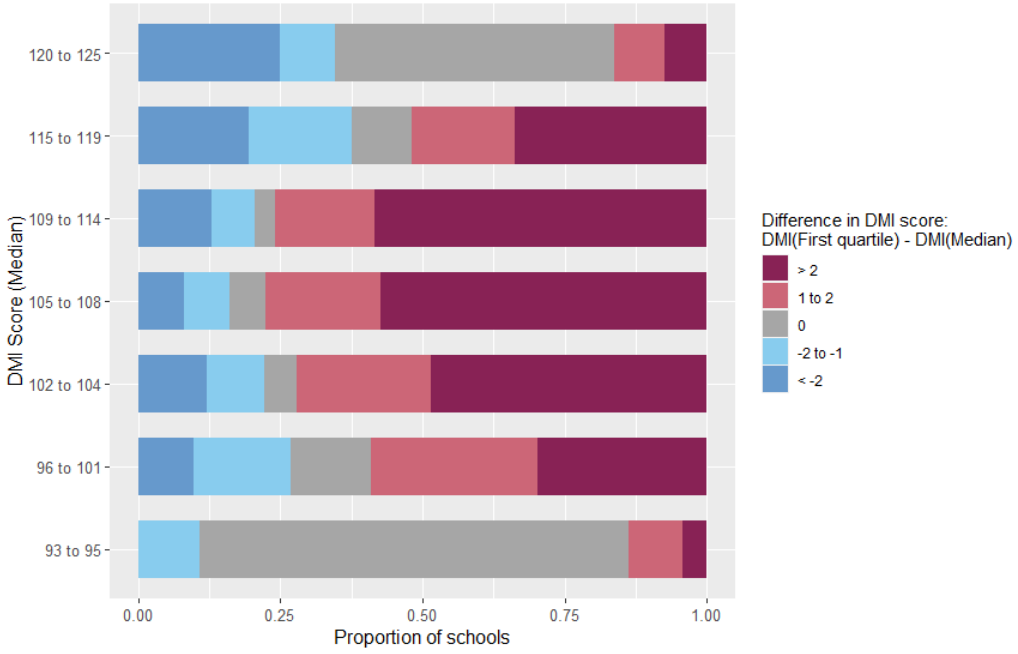


Figure 8: Distribution of differences between score based on first quartile and DMI score, 2020, by proportion of schools in each DMI score range.



Mid-hinge

Figures 9 and 10 show the difference between scores based on the mid-hinge and DMI scores in 2020, by 2020 DMI score range. For a large proportion of schools in the 93 to 95 DMI score range (78%) and the 120 to 125 DMI score range (68%), the score based on the mid-hinge is the same as the DMI score.

For schools with DMI scores between 102 and 119, the score based on the mid-hinge is lower than the DMI score for the majority of schools. Using the mid-hinge results in a decrease in score for 70% of schools in the 102 to 104 and 105 to 108 DMI score ranges, 63% of schools in the 109 to 114 DMI score range, and 52% of schools in the 115 to 119 DMI score range.

Figure 9: Distribution of differences between score based on the mid-hinge and DMI score, 2020, number of schools by DMI score range.

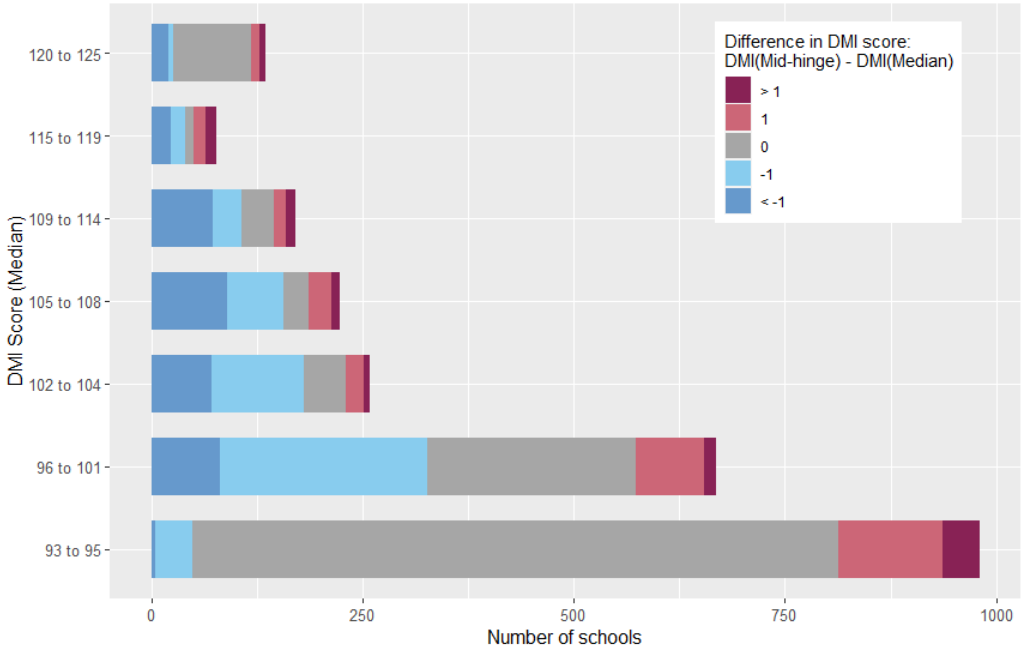
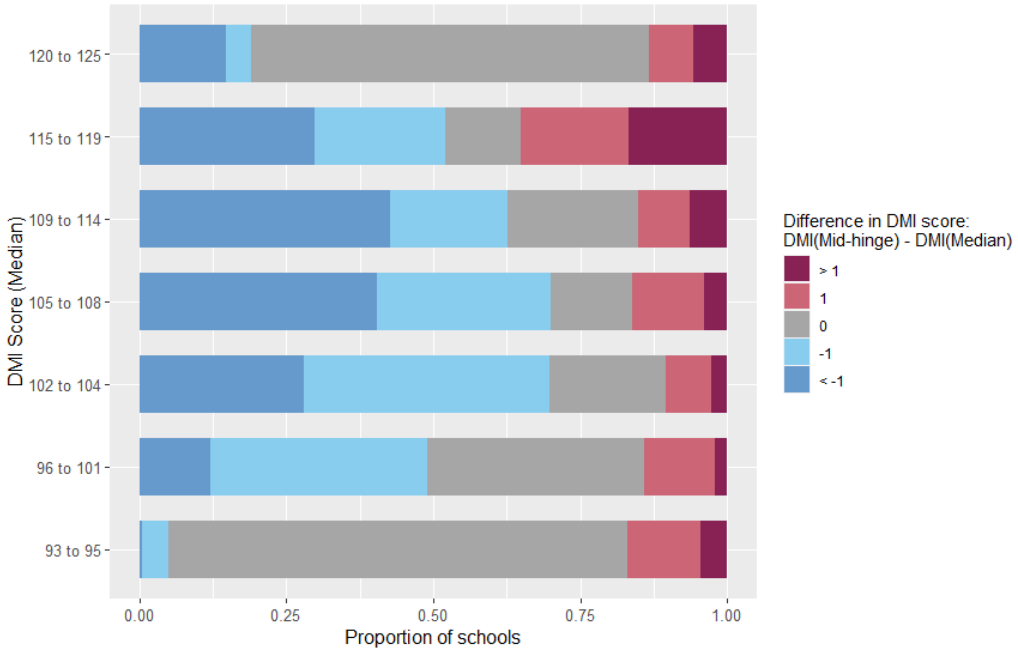


Figure 10: Distribution of differences between score based on the mid-hinge and DMI score, 2020, by proportion of schools in each DMI score range.



Tri-mean

Figures 11 and 12 show the difference between scores based on the tri-mean and DMI scores in 2020, by 2020 DMI score range. For a large proportion of schools in the 93 to 95 DMI score range (88%), the 96 to 101 DMI score range (59%), and the 120 to 125 DMI score range (74%), the score based on the tri-mean is the same as the DMI score.

For schools with DMI scores between 105 and 114, a majority of schools have a decrease in score when the tri-mean is used. There is a decrease in score for 50% of schools in the 105 to 108 DMI score range, and 59% of schools in the 109 to 114 DMI score range.

Figure 11: Distribution of differences between score based on the tri-mean and DMI score, 2020, number of schools by DMI score range.

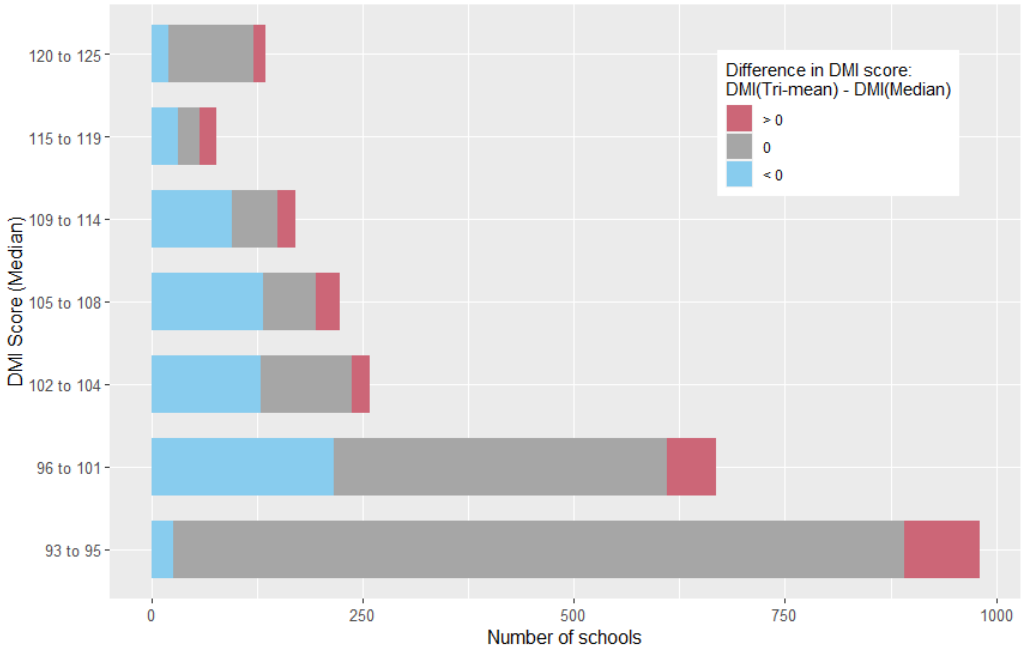
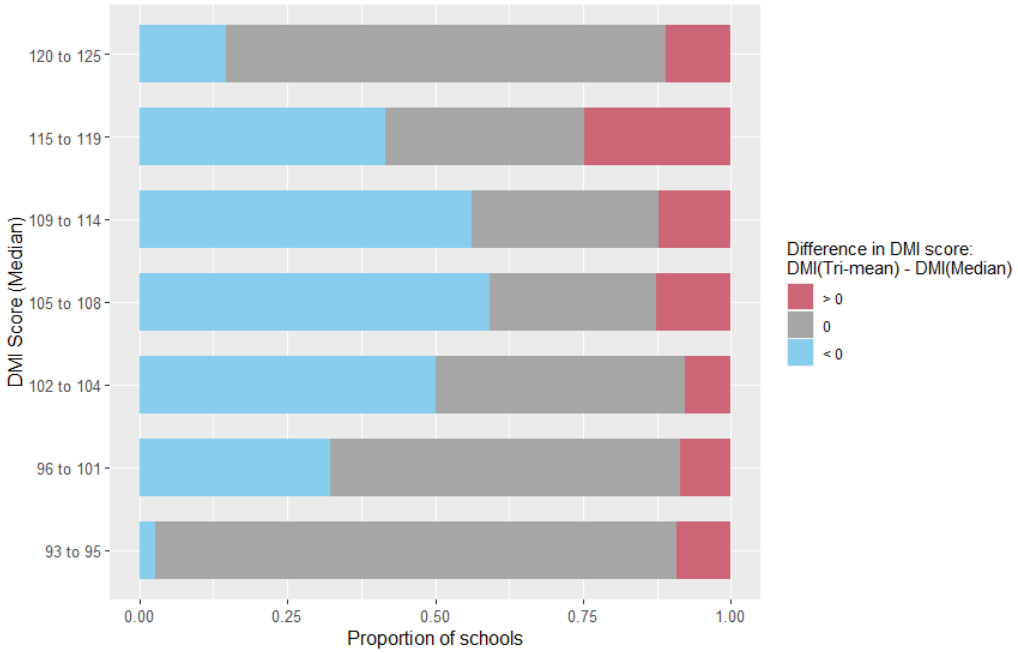


Figure 12: Distribution of differences between score based on the tri-mean and DMI score, 2020, by proportion of schools in each DMI score range.



Mean

Figures 13 and 14 show the difference between scores based on the mean and DMI scores in 2020, by 2020 DMI score range. For the majority of schools in the 93 to 95 DMI score range (64%) and the 120 to 125 DMI score range (53%), the score based on the mean is the same as the DMI score.

For schools with DMI scores between 96 and 119, the score based on the mean is lower than the DMI score for the majority of schools. Using the mean results in a decrease in score for 86% of schools in the 102 to 104 DMI score range, 83% of schools in the 105 to 109 DMI score range, and 84% of schools in the 109 to 114 DMI score range.

For over a third (35%) of schools in the 93 to 95 DMI score range, the use of the mean resulted in an increase in score.

Figure 13: Distribution of differences between score based on the mean and DMI score, 2020, number of schools by DMI score range.

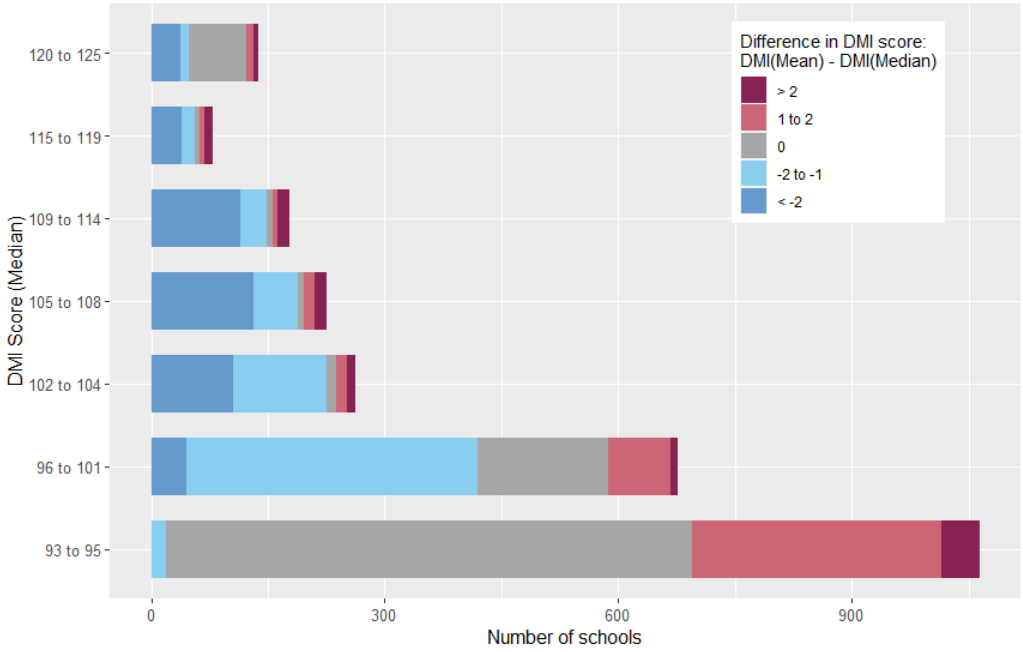
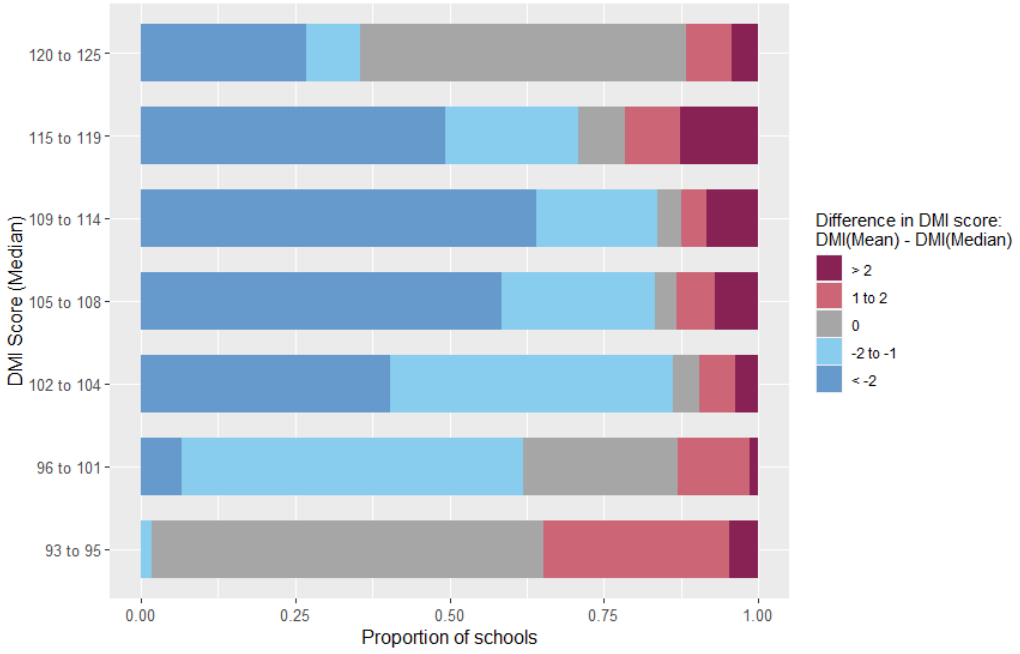


Figure 14: Distribution of differences between score based on the mean and DMI score, 2020, by proportion of schools in each DMI score range.



Trimmed mean

Figures 15 and 16 show the difference between scores based on the trimmed mean and DMI scores in 2020, by 2020 DMI score range. For the majority of schools in the 93 to 95 DMI score range (77%) and the 120-125 DMI score range (64%), the score based on the trimmed mean is the same as the DMI score.

Like scores based on the mean, for schools with DMI scores between 96 and 119, the score based on the trimmed mean is lower than the DMI score for the majority of schools. Using the trimmed mean results in a decrease in score for 77% of schools in the 102 to 104 DMI score range and 72% of schools in the 105 to 108 DMI score range.

Figure 15: Distribution of differences between score based on the trimmed mean and DMI score, 2020, number of schools by DMI score range.

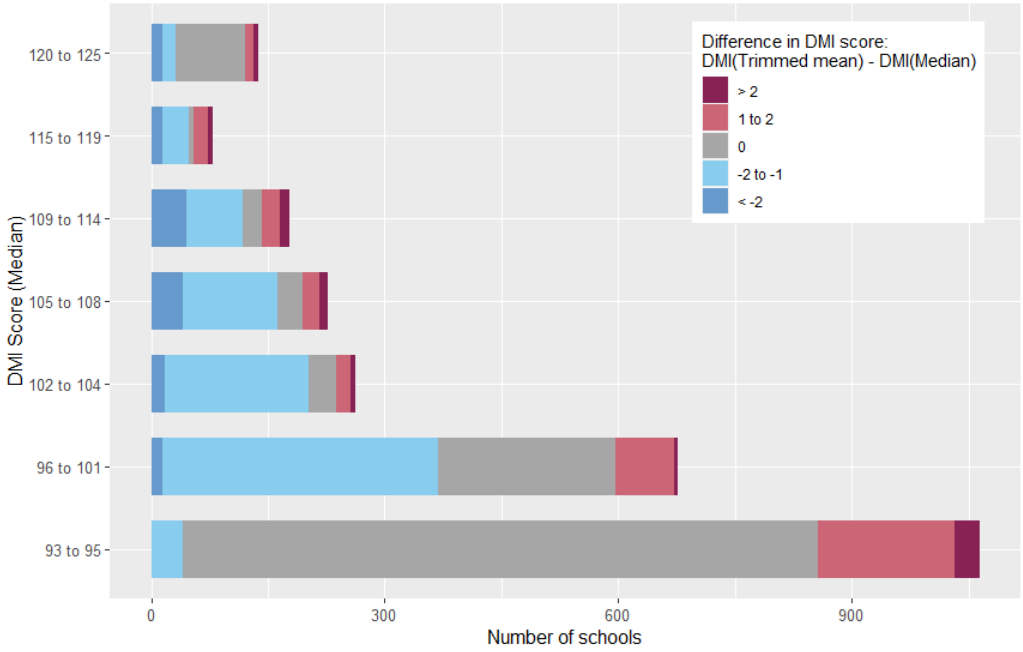
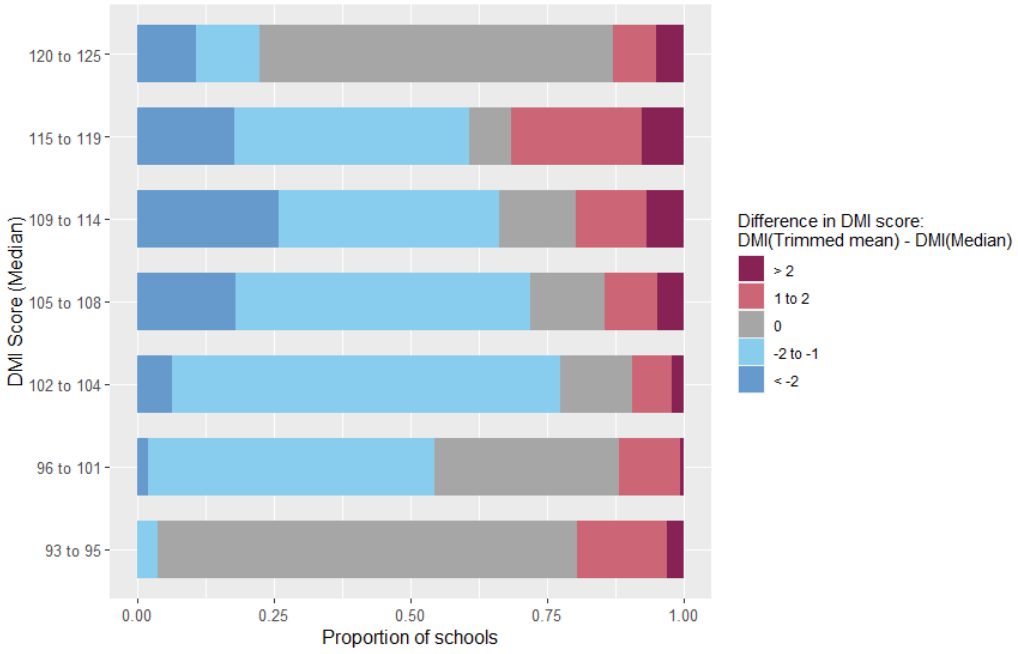


Figure 16: Distribution of differences between score based on the trimmed mean and DMI score, 2020, by proportion of schools in each DMI score range.



Winsorised mean

The distribution of differences in score based on the winsorised mean, by 2020 DMI score range, is similar to that of the trimmed mean.

Figures 17 and 18 show the difference between scores based on the winsorised mean and DMI scores in 2020, by 2020 DMI score range. For the majority of schools in the 93 to 95 DMI score range

(73%) and the 120-125 DMI score range (64%), the score based on the winsorised mean is the same as the DMI score.

Like scores based on the mean and trimmed mean, for schools with DMI scores between 96 and 119, the score based on the winsorised mean is lower than the DMI score for the majority of schools. Using the winsorised mean results in a decrease in score for 81% of schools in the 102 to 104 DMI score range and 78% of schools in the 105 to 108 DMI score range.

Figure 17: Distribution of differences between score based on the winsorised mean and DMI score, 2020, number of schools by DMI score range.

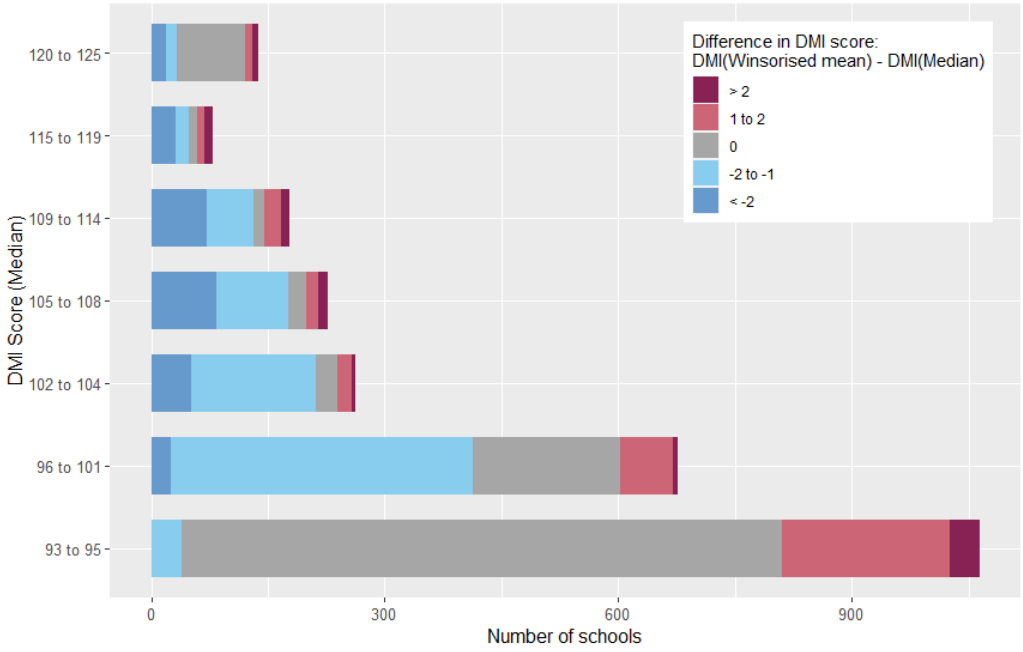
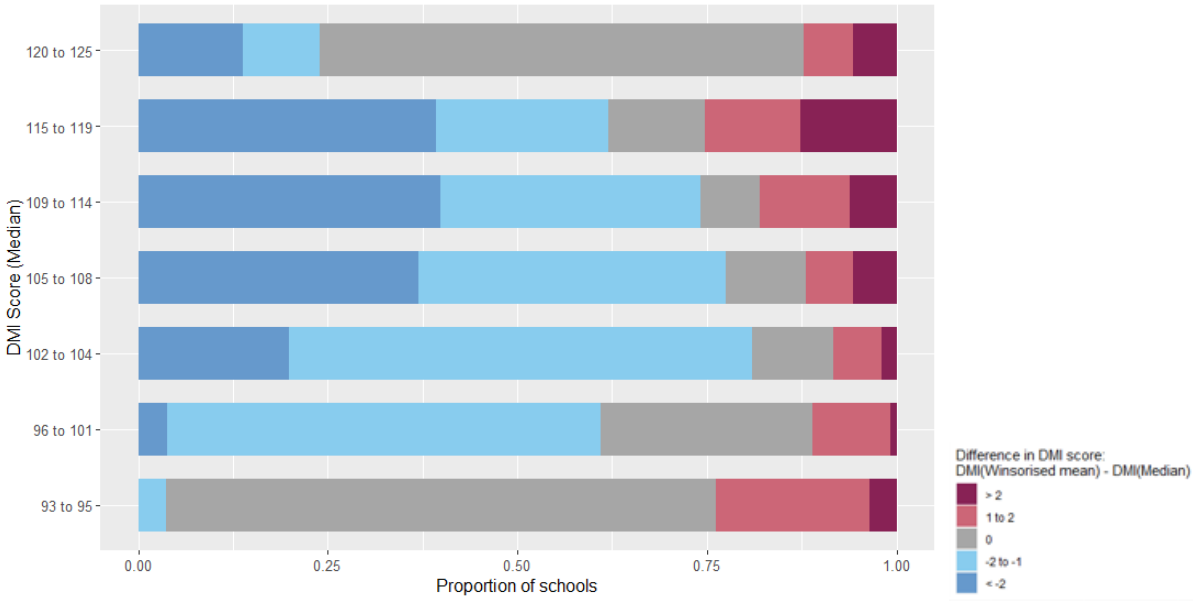


Figure 18: Distribution of differences between score based on the winsorised mean and DMI score, 2020, by proportion of schools in each DMI score range.



4. Volatility

This section presents preliminary analysis of the volatility of scores based on the alternative measures, compared with the median. Volatility is indicated by the change in a school's score over time.

Summary

Table 5: Summary of preliminary assessment of the volatility of alternative measures, 2018 to 2020.

Summary measure	Volatility
First quartile	Slightly less stable than the DMI score. Slightly fewer schools have no annual change in score, based on the first quartile than the DMI. Average score changes are slightly larger in magnitude than average changes in DMI score.
Mid-hinge	Slightly more stable than the DMI score.
Tri-mean	Slightly more stable than the DMI score.
Mean	Slightly more stable than, or similar to, the DMI score.
Trimmed mean	Slightly more stable than the DMI score.
Winsorised mean	Slightly more stable than the DMI score.

Detailed analysis

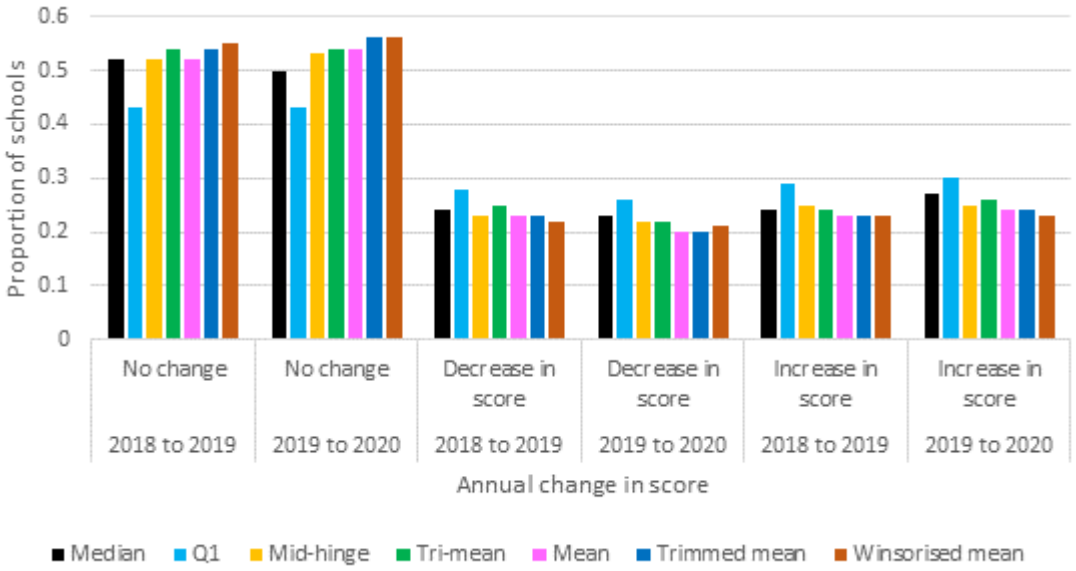
For each statistical summary measure, the annual change in each school's score is calculated as the score in a given year minus the score in the previous year. The scores are rounded and top and bottom coded at 93 and 125 prior to calculation of the annual change. Confidentiality requirements must be met in each year. This requirement affects the number of schools for which the change can be calculated, for each alternative measure.

Figure 19 shows, for each statistical summary measure, the proportion of schools which have no change in score, a decrease in score, or an increase in score, from 2018 to 2019 and from 2019 to 2020. For approximately half of schools, there is no change in DMI score (based on the median) from 2018 to 2019 (53%), and from 2019 to 2020 (50%). Approximately a quarter of schools have a decrease in DMI score each year (24% from 2018 to 2019 and 23% from 2019 to 2020). Approximately a quarter of schools have an increase in DMI score (24% from 2018 to 2019 and 27% from 2019 to 2020).

Similar proportions are observed for scores based on the alternative measures, except the first quartile, for which a slightly larger proportion of schools have an annual change in score. Based on the first quartile, a decrease in score occurs for 28% of schools from 2018 to 19 and 26% from 2019 to 2020. An increase in score based on the first quartile occurs for 29% of schools from 2018 to 19 and 30% from 2019 to 2020.

Overall, the other alternative measures appear slightly more stable than the DMI score. That is, they have a slightly higher proportion of schools with no annual change in score.

Figure 19: Proportion of schools, by statistical summary measure, with no change in score, a decrease in score, or an increase in score, from 2018 to 2020.

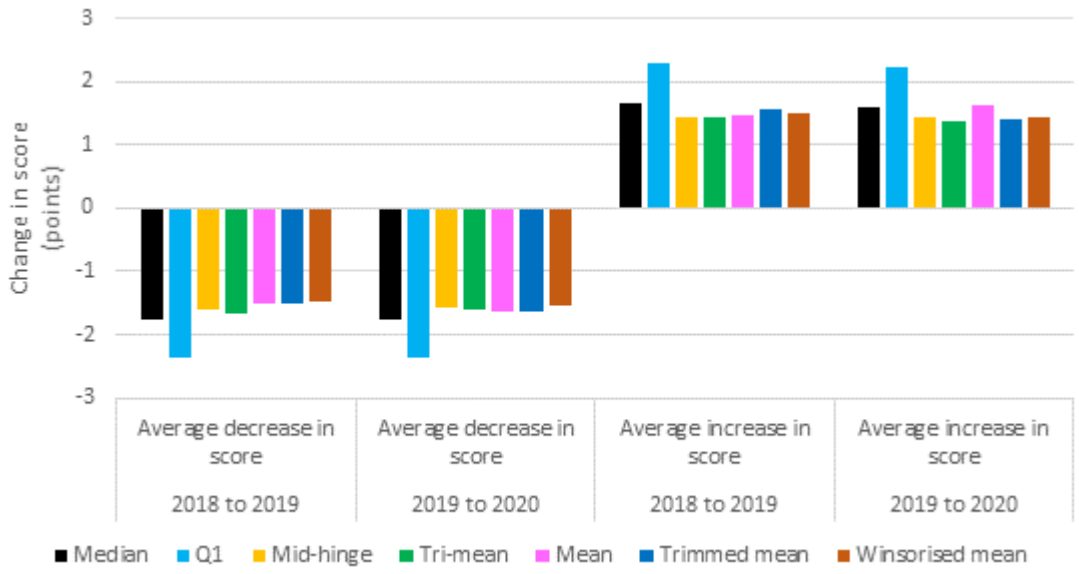


For schools which have a change in score, Figure 20 shows, for each alternative measure, the average size of the change. For schools which have a decrease in DMI score from 2018 to 2019, the average size of the decrease is 1.75 points and from 2019 to 2020, it is 1.76 points. (Decreases are shown as negative changes in Figure 20.) For schools which have an increase in DMI score, the average increase from 2018 to 2019 was 1.66 points, and from 2019 to 2020 it was 1.59 points.

For scores based on the first quartile, annual score changes were greater in magnitude than DMI score changes. The average score decrease, for scores based on the first quartile is 2.37 points in both periods. The average score increase, for scores based on the first quartile is 2.28 points from 2018 to 2019 and 2.22 points from 2019 to 2020. Overall, scores based on the first quartile appear slightly less stable than DMI scores.

For scores based on the other alternative measures, the average changes in score from year to year are generally slightly smaller in magnitude than changes in the DMI score. The exception is scores based on the mean, which increased by slightly more (1.63 points), on average, than DMI scores from 2019 to 2020.

Figure 20: Average size of score change, in points, by statistical summary measure, from 2018 to 2020.



5. Confidentiality

Confidentiality is fundamental to CTC

Protecting the privacy and confidentiality of individuals who make up the CTC population is a paramount consideration in the design and implementation of the DMI methodology.[5]

CTC data is protected by the Census and Statistics Act 1905, which strictly prohibits the release of information in a manner likely to enable the identification of a person. In addition, Australian Government agencies, including the ABS and DESE, are responsible for maintaining the confidentiality of those who provide information, in accordance with legislation such as the Privacy Act 1988.

In accordance with the 'five safes' confidentiality risk management framework, CTC data is stored securely in the ABS DataLab and only authorised researchers have access to it. Per the 'safe outputs' dimension of the five safes framework, confidentiality experts in the ABS vet all analytical outputs for CTC, prior to their release from the secure ABS DataLab. This ensures that agreed confidentiality requirements, as described in Safe Data Release for CTC, have been met.

Confidentiality risks associated with CTC data

Relevant areas across the ABS come together to consider the confidentiality risk of CTC data and the appropriate treatment to apply before data can be released. Factors which affect the risk level of CTC data include:

- the size of school populations, noting that they may be small;
- the annual release of school scores, which introduces the need to ensure that year on year changes are not disclosive;
- the fact that CTC is a direct measure of the school population, rather than (for example) an estimate based on a survey sample; and
- the provision of additional data to assist users to understand their scores (noting that in some cases scores are released while supporting information is suppressed).

The statistical summary measure

The choice of an alternative statistical summary measure has the potential to increase confidentiality risk. The median is a relatively low risk measure, because it only indicates the point at which half of the population's incomes are above and half are below. The first quartile, mid-hinge and tri-mean are similarly low risk.

Of the alternative measures, the mean represents the highest risk, because of the amount of information it contains about potential high income values (outliers). The trimmed mean and winsorised mean represent a higher risk than the median, but a lower risk than the mean, as they

[5] For further information about privacy and confidentiality of CTC data, see the DMI Refinement Working Group paper, Safe Data Release for Capacity to Contribute and A Data Quality Framework for the Australian Government's Direct Measure of Income for Capacity to Contribute. Both are available on the DESE website.

limit how much information can be gained about outliers (depending on the choice of trimming parameter or winsorisation threshold).

Treatment of data for safe release

Treatments commonly used to mitigate confidentiality risk and support safe data release include:

- Limiting the number of variables or statistics, or the level of detail provided.
- Ensuring the population or group represented is sufficiently large.
- Suppressing values which only represent a small group of people.
- Modifying values using perturbation (the making of small adjustments to data or tables).
- Top and bottom coding: for example, the bottom coding of low income values to the tax-free threshold of $18,200.

Depending on the statistical summary measure used, some or all of these treatments may be required for CTC.

Implications of using alternative statistical summary measures for CTC

Availability of scores

A key confidentiality requirement for the release of a school score is the minimum number of families whose incomes are included in the score. For the DMI score, this is defined as the number of families with non-zero income.

For the median, mean, trimmed mean and winsorised mean, the minimum is 10 families. For the first quartile, mid-hinge and tri-mean, it is 20 families. The minimum number of families required for these measures is higher because they are based on quartiles, which represent a greater level of detail than the median.

For the mean, trimmed mean and winsorised mean, it is also a requirement that a small number of family incomes do not represent a large proportion of the summary measure. This is known as the 'dominance rule', and further information about it is available in the ABS Confidentiality Series (cat. no. 1160.0, 2017).

If any of these criteria are not met, the score for a school cannot be used, and an alternative methodology is used to determine the school's CTC score.

Confidentiality risk associated with the annual release of school-level data must also be considered. In general, this risk is considered low, because it is expected that a new cohort of students, such as reception students, would join a school each year, and another cohort of students, such as graduating students, would leave. However, it is possible that a single family may join or leave a small school from year to year, and in such circumstances, it is necessary to ensure information about that family is protected.

For the median and measures based on the quartiles, this involves comparing the number of families and students in a school each year. For the mean, trimmed mean, and winsorised mean, the change in the statistical summary measure must also be assessed for dominance by a small number of families. Mitigating this confidentiality risk requires either:

- the perturbation of family incomes; or
- the application of the dominance rule to the change in the statistical summary measure from year to year. This requires the ability to compare each family's contribution to the statistical summary measure in consecutive years. That is, it requires the CTC data to be longitudinal. This is technically feasible; however, it would require changes to the privacy framework that is currently in place for CTC data.

Availability of supplementary information

The provision of supplementary information, such as income distribution information and data quality indicators, supports the implementation of the CTC policy framework, including the CTC review framework. It also supports the interpretability of school scores by stakeholders.

Under the DMI methodology, key quality indicators, such as the coverage rate (the proportion of students for which a family income is available), and income distribution information in the form of quartiles, are able to be released for a large majority of schools.

The same approach is feasible for the release of supplementary information under the first quartile, mid-hinge and tri-mean. For the mean, trimmed mean, and winsorised mean, releasing income distribution information in the form of the variance or standard deviation is likely to be feasible from a confidentiality perspective. However, further work would be required to develop a safe data release strategy for supplementary information to support scores based on the mean, trimmed mean or winsorised mean.

Availability versus accuracy, interpretability and complexity

In general, as the risk associated with releasing data increases, additional treatments are required, reducing the availability and / or utility of the data.

For example, under the current Safe Data Release strategy for the DMI score, income quartiles less than $18,200 are coded to that amount. Although this reduces accuracy, it protects confidentiality while having a negligible impact on school scores and on the interpretation of school scores. If the first quartile, mid-hinge, or tri-mean were used, this bottom coding would be applied as part of the calculation of school scores.

For the mean, trimmed mean, and winsorised mean, perturbation may be required to mitigate risks associated with these statistical summary measures. This would increase the availability of school scores, but may also increase the complexity of processing the data and reduce its accuracy and interpretability. A potential implication of increased complexity of the CTC score production process may be reflected in the time taken to develop a safe data strategy and produce and vet school scores and supporting information each year. Similarly, if the trimmed mean or winsorised mean were used, the trimming parameters or winsorisation threshold may need to be optimised and reviewed periodically, as incomes change over time. This may also necessitate a review of the corresponding safe data release strategy.

Summary

Table 6 summarises the key risks, confidentiality requirements and potential implications for each statistical summary measure.

Table 6: Key risks, confidentiality requirements for statistical summary measures and potential implications of using alternative statistical summary measures for CTC.

Statistical summary measure	Risk rating of measure	Minimum number of contributors to score	Dominance rule required	Treatment of data	Availability of supporting information	Impact on privacy framework
Median	Low	10 families	No	Simple: Bottom-coding: ≤ $18,200.	Quality indicators and income quartiles, per Safe Data Release Strategy for CTC.	No
First Quartile	Low	20 families	No	Simple: Bottom-coding: ≤ $18,200.	Same as median.	No
Mid-hinge	Low	20 families	No	Simple: Bottom-coding: ≤ $18,200.	Same as median.	No
Tri-mean	Low	20 families	No	Simple: Bottom-coding: ≤ $18,200.	Same as median.	No
Mean	High	10 families	Yes	Complex: Bottom-coding: ≤ $18,200. Perturbation may be required	Requires development. Standard deviation or variance likely to be available.	Yes, if perturbation is not applied.
Trimmed mean	Medium	10 families (after trimming)	Yes	Complex: Bottom-coding: ≤ $18,200. Perturbation may be required	Same as mean.	Yes, if perturbation is not applied.
Winsorised mean	Medium	10 families	Yes	Complex: Bottom-coding: ≤ $18,200. Perturbation may be required	Same as mean.	Yes, if perturbation is not applied.

6. Next steps

In this paper, the ABS has proposed a conceptual framework consisting of six principles with which to assess the fitness-for-purpose of the alternative statistical summary measures for use in the DMI methodology. The ABS welcomes feedback from the DMI Refinement Working Group on this framework, noting that that there may be other principles of importance to stakeholders, and that the importance placed on each principle may not necessarily be equally weighted.

The ABS has also presented preliminary analyses of the first three principles:

(1) relative orientation to the DMI score;
(2) volatility; and
(3) confidentiality.

The ABS will present analyses of the remaining three principles in March 2021, subject to feedback from the DMI Refinement Working Group on the proposed framework. These principles are:

(4) accuracy;
(5) robustness to extreme values; and
(6) sensitivity to distributional differences.

Appendix 1: Definitions of selected statistical summary measures

Statistical Summary Measure	Definition
Median (or second quartile, Q2)	After sorting all family incomes in ascending order, the middle value or the average of the middle two values (depending on whether the dataset has an odd or even number of incomes respectively).
First quartile (Q1)	Similar to the median, but is instead the income value that lies 25% of the way through the ordered set of income values.[6]
Mid-hinge	The average of first quartile and the third quartile (Q3) [7] of the school community's income distribution; that is: $\text{Mid-hinge} = \frac{Q1+Q3}{2}$.
Tri-mean	The weighted average of the first quartile (Q1), the median (Q2) and the third quartile (Q3) of the school community's income distribution; that is: $\text{Tri-mean} = \frac{Q1+2*Q2+Q3}{4}$.
Mean[8]	The sum of all income values in the school community's income distribution divided by the number of income values in the distribution. That is, if there are n income values in the distribution, then: $\text{Mean} = \frac{\sum_{i=1}^{n} x_i}{n}$.
Trimmed mean[8,9]	Calculated by discarding extreme income values (either a certain number or proportion) from one or both sides of the school community income distribution and only using the remaining values in the calculation of the mean. If the number of discarded values is m, then the trimmed mean is the sum of the remaining (n-m) values divided by (n-m), not n.
Winsorised mean[8,9]	Similar to the trimmed mean but the extreme income values are dampened or brought closer to a pre-determined, less extreme value and are still used in the calculation of the mean, instead of being discarded.

[6] Note that if the 25% mark falls between two income values in the distribution, then Q1 is an appropriately weighted average of those two income values.
[7] Note that Q3 is calculated in a similar manner to Q1, but is instead the income value that lies 75% of the way through the ordered set of income values.
[8] If the mean, trimmed mean or winsorised mean is chosen, a decision will need to be made regarding the treatment of negative incomes. For the purposes of the analysis described in this report, any negative incomes identified in the data will be treated as zero in the calculation of means.
[9] Note that if the trimmed mean or winsorised mean were to be used in the DMI methodology, significant further investigations and decisions would be required to determine the method and amount of trimming or winsorisation to be applied to school community income distributions.